Bringing New Bananas to the Canadian Market

IDRC Experience with the FHIA Varieties

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Introduction

This paper reviews the work supported by the FoodLinks Initiative on sustainable production-to-consumption chains in bananas. Since the early 1970s, the International Development Research Centre (IDRC) has supported projects on the sustainable development of banana and plantain recognizing their importance in food security and the threats posed by disease for this crucial food and income crop for millions of small farmers around the world. Since 1985, IDRC has funded a series of research projects in Honduras aimed at improving natural resistence to black Sigatoka disease in both bananas and plantains for small- and medium-scale landholders, for both domestic and export consumption. In 1995, after 10 years of research, two dessert banana varieties appropriate for local subsistence as well as potentially for export markets were released to farmers throughout the world. These varieties, developed at Fundación Hondureña de Investigación Agrícola (FHIA, Honduran Foundation for Agricultural Research), became the focus of the work presented here.

In 1995, based on IDRC's past experiences with bananas and plantains, the FoodLinks Initiative worked to bring both the varieties FHIA-01 ('Goldfinger') and FHIA-02 ('Mona Lisa') to the North American market. A project that is somewhat unconventional in IDRC's context because of its agribusiness–export orientation, it addresses fundamental, pressing issues in southern countries. Although export banana trade represents only 10% of the total world banana consumption, its social, environmental, and economic impacts show a clear need for more sustainable practices because chemical spraying to control black Sigatoka have significantly increased with severe implications. It is to this need that the IDRC FoodLinks' *Bringing New Bananas to the Canadian Market* project speaks.

Research and market trials of these varieties have been the mechanism aimed at increasing the incentive for producers to enter into more sustainable banana production. These efforts, the latest ending in May 1998, are outlined in this report, which aims to provide the most up to date information on both 'Goldfinger' and 'Mona Lisa' in Canadian markets.

The paper is comprised of three main segments. The first provides the general context for the current project detailing past foundational IDRC projects in bananas and plantains leading up to the first 'Mona Lisa' market trials. The second describes the first trials, highlighting the initial investigative and publicity work as well as the new postharvest results collected. Finally, the third section provides the technical (postharvest and marketing) results derived from the second and final trials.

Project Context

Defining the Context of Bananas

Bananas and plantains are one of the world's most important crops for small-, medium-, and large-scale growers alike. Generally speaking, 90% of all the bananas produced are grown by small-scale, subsistence landholders and consumed locally (IDRC 1998a) while the remaining 10% form the international export banana trade. For the smallholder, bananas and plantains provide food security as an important staple crop while also providing income potential through

> *The FoodLinks initiative meets a pressing need for innovative approaches to sustainable development: it links Northern private enterprises to producer groups in developing countries in market-oriented research and business partnerships. Addressing key issues that constrain small producers and processors in developing countries from more profitable, value-added activities, the FoodLinks Initiative aims to maximize returns to the community (FoodLinks 1997a).*

local markets. They can be used in intercropping systems and are fully used in food preparation and animal husbandry. The other 10% of global banana production in its enormous volumes is “the fourth most important commodity and as a fruit rank[s] first” (Frisson et al. 1997, p. 6). For banana-producing nations, which are mostly in the developing world, they represent a source of employment and of foreign currency. For example, in 1980, total employment in the six most important banana-producing countries in Latin America reached 374,400 people (Cordova 1992). Within these same countries, bananas accounted for up to 32% of the total value of all exports. In their countries of destination, export bananas are also an important food representing the highest volume item in most supermarket produce departments. With recent developments in China and the former USSR, these trade volumes continue to increase, in 1996 reaching the unprecedented levels of 11.5 million tonnes (FAO 1998).

Given the importance of bananas and plantains in developing countries for food security and for incomes, IDRC has invested in over 30 projects since 1971 to improve production and handling capabilities mostly at the subsistence and smallholder level (Appendix 1). Historically, IDRC projects within this field have been multidisciplinary, making extensive use of cross-cutting analysis from agronomic science, economics, and social science perspectives. Areas of work and study have included: environmental policy, economics and rural development, business and market studies, information for development, information network building, information dissemination, crops production systems, and finally postproduction systems related to both shelf life and processing.

IDRC has particularly invested in the development of better banana and plantain varieties that could address the problems caused by banana diseases, most importantly black Sigatoka. This fungus attacks leaf tissue and reduces productive capacity, yields, and postharvest life of the fruit. If left untreated, it may destroy entire plants. For the small-scale landholder without resources to invest in plant protection, a valuable source of food and income may be lost. For the export industry, it means dependence on socially, environmentally, and financially costly pesticides.

The export-banana industry is marked by its dependance on an extremely narrow genetic base for production. The ‘Cavendish’ variety is currently the only one widely available for export markets. Unfortunately, this variety is also extremely, and increasingly, susceptible to black Sigatoka and other important diseases affecting banana crops. Because of this susceptibility, ‘Cavendish’ needs repeated fungicidal treatment. From an environmental perspective, the consequences of this treatment are well known — a bibliography of studies highlighting their effects has been provided (Appendix 2) along with a table of some of the toxicological and ecological effects of the chemicals used specifically against black Sigatoka (Appendix 3). From a political econometric perspective, the technology used in black Sigatoka control favours the larger producer, having a rationalizing effect on the industry from a production standpoint (Sauvé

1998a). Finally, the control of this disease is a heavy financial burden at both farm and country levels. At the farm level, increasing input costs for fungicides reduces profits by increasing production cost. "For example, in Honduras in 1984, black Sigatoka control was approximately 26% of the cost of producing a box of bananas" (Johanson 1996). At the country level, expenditures on black Sigatoka fungicides from 1980 to 1992 in countries belonging to the Union of Banana Exporting Countries (UPEB) were estimated to have increased by 45% from 72 million USD (United States dollars) to 127 million (Cordova 1992). In the end, it is the susceptibility of the 'Cavendish' variety that can be held partly responsible for this situation and thus its replacement by more disease-resistant varieties can be seen as part of the solution.

Building on a New Disease-resistant Variety

In 1960, as a response to the susceptibility to Panama disease of the 'Gros Michel' export banana, the United Fruit Company began a research initiative to find alternative disease-resistant bananas (INIBAP 1994, p. 38). Their efforts continued until 1984 when this initiative was donated to FHIA. By 1984, the 'Cavendish' was solidly placed as the pre-eminent export-banana variety and, although black Sigatoka and other important diseases were already present, fungicides and other pesticides seemed effective in their treatment.

In 1985, IDRC began supporting a multiphase project at FHIA that would set the foundation for future banana work at the FoodLinks Initiative. From the beginning, it was recognized that "in Honduras, the relatively new black Sigatoka leaf spot disease poses a serious threat" (IDRC 1998b). Each of the four phases of this project focused on genetic improvement through traditional breeding to confront black Sigatoka in both bananas and plantains (Table 1). By 1995, at what is now the oldest banana breeding facility in operation, FHIA commercially released the varieties FHIA-01 ('Goldfinger') and the FHIA-02 ('Mona Lisa') hoping they would be adopted within conventional and organic banana markets. These varieties show a much higher resistence than 'Cavendish', which has little or no tolerance, to black Sigatoka and other diseases affecting bananas (Guzman and Romero 1996, p. 62). In particular for 'Mona Lisa', results have shown that, at the Corporación Bananera Nacional (CORBANA) research site, organic production methods outperform the conventional in terms of number of hands produced by bunch, height, and number of leaves (Laprade 1996, p. 105; Vernooy 1996, p. 9; Rosales 1997, p. 15). It is these varieties and most recently the 'Mona Lisa' variety that form the emphasis of FoodLinks' work.

IDRC, FoodLinks, and the FHIA varieties

IDRC work in commercialization of the 'Goldfinger' and 'Mona Lisa' varieties is carried out in the FoodLinks Initiative. FoodLinks seeks to identify incentives (market demand, partners, promotional points, and consumer interest) for the adoption of sustainable technologies and

> *FoodLinks' goal is to generate, and broker knowledge, strengthen research and development capacity in the agri-food enterprise field, and to facilitate the implementation of a range of market-orientated strategies in the agri-food sector that support sustainable development (FoodLinks 1997b).*

Table 1. Main objectives of four IDRC projects in support of banana improvement.

Project/phase	Main objectives
Plantain/Banana Improvement (Honduras) — Phase I, 1985	Upgrade the agronomic qualities of disease-resistant diploids and to breed plantains with resistance to black Sigatoka
Plantain / Banana Improvement (Honduras) — Phase II, 1989	Provide continued support for breeding work on bananas and plantains, to help strengthen efforts to develop resistance to black Sigatoka
Plantain / Banana Improvement (Honduras) — Phase III, 1992	Produce improved varieties of plantains and bananas to overcome production constraints among which the black Sigatoka disease is the most important
Goldfinger, Cooking Bananas and Plantains: Testing and Dissemination (Uganda and Ghana), 1996	Halt the decline in production of plantains and bananas for local consumption caused by the effects of Sigatoka, by making available to small and medium scale African farmers improved disease-resistant, high-yielding hybrids from FHIA
Total Investment	1 512 940 CAD (Canadian dollars)

Source: IDRIS (1998).

practices in the development of environmentally sound businesses. In the case of *Bringing New Bananas to the Canadian Market*, 'Goldfinger' and 'Mona Lisa' are seen as sustainable technologies because they are naturally more tolerant to pests and disease as a result of their breeding. FoodLinks sees the potential for these varieties, through market mechanisms and links to private-sector partners, to address the increasing environmental, social, and economic costs of black Sigatoka and other banana diseases in the export trade. Investing in market development for FHIA varieties through research and education creates positive incentives to encourage sustainable banana production. Within the "organic" food industry, as is the case for bananas, this sustainable production can also carry with it higher returns to the growers. Within FoodLinks' main goal — to implement "market-orientated strategies in the agrifood sector" — it wishes to help set the example of a successful, sustainable banana development" initiative (FoodLinks 1997b). It is hoped that, with success, will come others who recognize that market and sustainable development goals can work together. Research and education, central in FoodLinks' mission statement and objectives (Appendix 4), are needed to support such new initiatives so that they may have a positive effect that will shape our future.

Bringing New Bananas to the Canadian Market has focused on the 'Mona Lisa' variety in the Canadian organic-food market. The project goal is to work with private-sector partners involved in produce ripening, wholesaling, and retailing as well as with grower(s) to test the viability of 'Mona Lisa' throughout the full production-to-consumption chain. Through a series of trials, FoodLinks would attempt to determine the best conditions for handling of the product and also to gauge its consumer acceptance. With positive results, a market link would be created and other growers would be encouraged to produce using this technology in a sustainable way. *Bringing New Bananas to the Canadian Market* "addresses directly the objectives of sustainable and equitable development by interlinking the environmentally sound production of bananas, the social organization of [small- and medium-scale] farmers and the marketing of organically certified products" (FoodLinks 1996, p. 2).

However, before even the first trials were set to begin, important work had already started to set the stage. In September 1994, the public relations team at IDRC staged a press conference for 'Goldfinger' at the Ontario Food Terminal (produce distribution centre) in Toronto. Reporters from local and national media in radio, print, and television were all present. Representatives from both FHIA and 'Friends of the Earth' were also on hand to help present the results of the *Banana/plantain improvement (Honduras)* project to the Canadian public. The press conference was a resounding success prominently placing the story and the results of FHIA research to the fore. Goldfinger bananas were tasted by produce buyers, chefs, and shop owners, who indicated their satisfaction with the product. Although no bananas were available for sale at that point, the conference's success encouraged IDRC to explore how to bring these bananas to the Canadian market.

Building on the initial success and interest generated at the Ontario Food Terminal media event, in September 1995, the newly formed FoodLinks Initiative began work with the University of Guelph to research the marketing potential of a fresh or processed 'Goldfinger' banana. At that point, 'Goldfinger' had just been released to producers so the report simply compiled all information to date on the product such as nutritional characteristic, harvest and postharvest behavior. Although results of an Australian consumer survey appeared positive, lack of interest from Canadian distributors and a taste thought too "tart" for the North American market convinced FoodLinks not to pursue further the commercialization of this particular variety. In September 1996, FoodLinks distributed samples of 'Mona Lisa', with its more distinctive flavors and aroma, at the Canadian Natural Products Association (CNPA) show in Toronto. With the emphatic support for the taste of the 'Mona Lisa' by Canadian distributors, this variety became the focus of work. In October 1996, the 'Mona Lisa' was featured at the Montreal World Congress — Congrès mondiale de la conservation de la nature — of the International Union for the Conservation of Nature and Natural Resources (IUCN). Once again the media was quick to pick up the story and waited in anticipation for the product to reach the market.

First Trials

On the heels of the successful media events, IDRC FoodLinks moved to investigate the introduction of the 'Mona Lisa' into the marketplace. In early 1997, an agreement was facilitated by FoodLinks between a Costa Rican producer of certified organic 'Mona Lisa' and a major Canadian chain supermarket operation for the distribution of 240 cases of product per week to about 70 retail outlets in Ontario. Because previous market attempts by this producer with 'Mona Lisa' showed negative results with respect to shelf life during shipping, applied research on postharvest was the core emphasis in these first trials. To this end, a grant was awarded to the University of Costa Rica (Centro de Investigaciones Agronómicas Laboratorio de Technología Poscosecha) with the objective of improving postharvest knowledge of the 'Mona Lisa' sufficiently to allow its successful shipping, ripening, and distribution in North American and European markets.

This study set out to address five important research topics (reported by Saenz 1998a; Appendix 5):

- Observations of the ripening behaviour of ‘Mona Lisa’ bananas;
- Exploratory tests to extend the postharvest life of ‘Mona Lisa’ banana;
- Storage at subnormal temperatures of ‘Mona Lisa’ bananas;
- Preliminary tests on the commercial ripening of ‘Mona Lisa’ bananas; and
- Latex control in ‘Mona Lisa’ bananas.

The results of this investigation, which drew from existing information and filled in the gaps with new original research, resulted in a recommended protocol (Table 2) derived from Saenz (1998a).

Table 2. Recommended protocol for harvest and postharvest treatment of bananas.

Harvest

Bunches are harvested after 12–13 weeks hanging, that is, after the flower has emerged and bent down. At this age, the fruit is properly mature, well shaped according to the variety, and able to reach edible maturity.

Harvesting is done according to conventional methods for bananas taking care to avoid mechanical damage.

Flower removal and separation of hands

Flowers are removed according to the conventional methods for bananas and separation of hands is also conventional. However, because of the shape of the hands and usefulness in preventing crown rot spreading to fingers, it is important that enough crown (part of the bunch axis) be left on the hand.

Hands are placed in a water tank with continuous flow for at least 15 minutes to remove latex. In the tank, calcium or sodium hypochlorite (chlorine bleach) is used at a concentration of 200 ppm to reduce the risk of crown rot. Concentrations of chlorine must be checked frequently as it is inactivated by organic matter such as latex.

Packing

Hands are packed in standard 40-lb export banana boxes (18 kg) using an internal liner of polyethylene of the open tubular type. The open liner will allow air exchange and prevent the accumulation of gel type latex in the bottom of the box. In preliminary experiments, high density unperforated polyethylene liners showed better green life than either perforated or low density liners (Appendix 5, *Exploratory tests to extend the postharvest life of ‘Mona Lisa’ banana*).

Four packages of 7 g each of potassium permanganate (PP) on a porous base (silica, clays, or so on) Must be placed in each box. Potassium permanganate oxidizes the ethylene thus preventing in-transit ripening and protecting both ‘Mona Lisa’ and ‘Cavendish’ in the case of a mixed shipment. In preliminary experiments, the use of four packages of 7 g each reduced the rate of ripening so that fruit treated with PP needed 24 days to reach stage 4 as compared with control fruit that required only 10 days.

Marine Transport Container

In a mixed shipment, the temperature must be between 12.8–14.4°C, which is safe for 'Cavendish'. In preliminary experiments, it was demonstrated that 'Mona Lisa' can withstand lower temperatures than 'Cavendish' without showing any symptom of chilling injury (Appendix 5, *Storage of 'Mona Lisa' bananas at subnormal temperatures*).

In a mixed shipment, 'Cavendish' is packed in the standard way for this variety with the exception of using a bana-vac liner (sealed polyethylene bag), isolating the 'Cavendish' from the outside air that may be contaminated with ethylene produced by 'Mona Lisa'. Treatments for latex, crown rot, and so forth, are standard.

In a full container shipment of 'Mona Lisa', cylinders of potassium permanganate are placed in the return duct of the refrigeration system to remove any ethylene produced by the 'Mona Lisa'.

Three temperature recorders (Ryan, for instance) should be placed, one into a 'Mona Lisa' box, one into a 'Cavendish' box, and the third for monitoring air temperature.

Ventilation slots should be 50% open to allow air exchange with the outside unless external temperature is so low that may damage the fruit.

Fruit arrival

Upon arrival, 'Mona Lisa' fruit must be placed in a room at 20ºC for at least 24 hours. Preliminary experiments have shown that when 'Mona Lisa' has not reached ambient temperature (20–24ºC) before the ripening process, uneven ripening and failure to ripen has resulted.

Fruit ripening

Lower ethylene concentrations than conventional should be used, for example one-quarter of catalytic in a 36-hour cycle. Other ripening procedures are standards.

In preliminary experiments, lower temperature in ripening — such as 13.3°C rather than 15.5°C — has shown a tendency to produce a better shelf life. Also, for fruit at 13.3°C, doses of ethylene had a statistically significant effect (with normal doses of ethylene, the fruit showed 3 days of shelf life as compared to 4.25 days under half doses). Further, normal doses had a significant effect on fruit quality producing a sticky flesh. At both 15.5°C and 13.3°C ripening, soluble solids was 20% at half ethylene doses and 17.25% at full doses.

Because these results were found in Costa Rica where conditions are quite different from those in more northern countries, they are merely a reference.

After ripening

Once the ripening has been initiated, 'Mona Lisa' can reach stage 5 very quickly. Therefore, to have enough time for distribution, fruit can be kept at 14–15ºC for up to 1 week. Once ripe and ready to eat, 'Mona Lisa' fruit has 19–22 Brix, and a subacidic flavour with a residue of astringency at the end.

Based in this protocol, the recommendations were tested in a full market trial. Shipments of 240 boxes for a total of 10 weeks were distributed to about 70 supermarket outlets in Ontario by a major Canadian chain supermarket wholesaler. This chain had just recently begun experimenting with "organic" sections in some of their stores and the 'Mona Lisa' banana fit well with this program. In their stores, bananas were the "Number one" volume produce item and so company officials were very optimistic about the performance of the 'Mona Lisa'. In a support role, FoodLinks provided the wholesaler with the new technical handling information, logistical support to liaise with the producer, as well as a specialist from the University of Costa Rica to follow the product from field to ripener. The fruit, coming from a small (25-ha) plantation in Costa Rica, was harvested and packed according to the protocol (Table 2). It was transported in a mixed load with 720 cases of 'Cavendish' packed at first according to the protocol than after mid-way through the trials in a standard (for the North American market) polyethylene liner. No effects were noted. According to upon-arrival assessments by company officials, the product arrived green with satisfactory quality. The general quality upon arrival of the fruit's first shipment showed (Saenz 1998a): 25% of product with "some degree of latex problems — either a transparent film in some areas or brown–black areas of latex that deposited after packing"; 20% of the fruit with some degree of physical damage; and 12–15% of the fruit showing problems normally associated with insects. This level of quality, although certainly leaving room for improvement, was fairly well received among the wholesalers who compared them to other organic bananas. Although some quality issues relating to bruising, latex, and insect damage were important, they could be solved at the production site. These trials, building from the preliminary research work, marked the first successful market trial resolution of the ethylene and storage problems prior to ripening. Replicated for 10 shipments, 'Mona Lisa' arrived green in acceptable condition. In ripening, however, problems arose. During ripening, it was noted by a Canadian technician that the fruit had "mushy" flesh (Saenz 1998a) and throughout all the trials, retailers indicated that the fruit was continually arriving over ripe at the stores (Sauvé 1998b). As indicated in the preliminary experiments, both of these characteristics (sticky flesh and reduced shelf life — Appendix 5, *Preliminary tests on the commercial ripening of 'Mona Lisa' bananas*) result from a combination of higher temperatures and ethylene doses during ripening. Unfortunately, with the comparatively small volumes of 'Mona Lisa' being handled (240 cases per week in an operation with a turnover of up to 30 containers per week), the opportunity costs for the technicians at the Canadian wholesaler to spend the time in learning about 'Mona Lisa' and more importantly to dedicate a full room to ripen them separately resulted in 'Mona Lisa' being ripened with 'Cavendish' bananas at high ethylene concentrations. With overripened product continually being released to the stores and a lack of information from the wholesaler/ripener, the situation even with full technical support offered by FoodLinks could never be fully rectified and thus major quantities of product were dumped. After 10 shipments, the trials were discontinued. It was clear that this banana was significantly different in ripening to the 'Cavendish' and would require more controlled trials for proper adherence to the protocol to ensure ripened fruit suitable for distribution and marketing.

The significant accomplishments coming from these first trials include:

- The postharvest handling protocol for 'Mona Lisa' was further defined in terms of shipping container protocol as well as harvesting/selection standards at the farm level to ensure better quality, and
- The first successful implementation of a green life shipping protocol for 'Mona Lisa' in North America which resulted in 10 successful shipments of green bananas to ripeners in North America.

Although the harvest, packing, and marine transport sections of the recommended protocol were confirmed, questions relating to the ripening of the fruit and distribution remained unconfirmed. A second set of FoodLinks trials of the 'Mona Lisa' were planned to answer these questions and further understand consumer acceptance to this product. Based on these trials, a comparison chart was developed citing physical, flesh, quality, shelf life and ripening differences between the 'Mona Lisa' and the 'Cavendish' (Appendix 6).

Second Trials

In May 1998, IDRC conducted a final one-time trial shipment to answer the questions remaining from the first trials. The goals of this effort were three-fold:

- To test the improvements made with respect to quality in terms of physical damage (insect and mechanical), red spot, grey spot, separation of hands, latex production, and weak necks;
- To evaluate shelf life through to retail under controlled ripening and distribution conditions outlined in a recommended protocol; and
- To investigate consumer acceptance of the 'Mona Lisa' banana.

Methodology

This trial involved a one-time shipment, monitored from field to consumer, of 96 cases of 'Mona Lisa' to five stores within the Ottawa region (Ontario, Canada). One pallet was to be distributed each week for 2 weeks. Because some of the problems during the first shipment involved farm-level quality control, monitoring of adherence to protocol was extended in depth to field-level details.

At 6:30 am on Tuesday 12 May, the harvest of one pallet each of 12- and 13-week hanging fruit began. All fruit used at the field level had been bagged with pin-hole polyethylene (to control insects) at the emergence of the flower and treated periodically with organically certified copper sulfate (to avoid red spot and eliminate grey spot). Bunches were brought to the packing house within 30 minutes of harvest using cushion pads to carry them to the cableway system, which brought the bunches to the packing house. All bunches arrived at the packing house still covered in a polyethylene bag (to limit mechanical damage).

Flower removal and selection of hands were standard. Selected fruit for the first pallet was placed in a continuous-flow water tank for 60 minutes and for the second pallet for 25 (to remove latex). No difference was noticed between the two groups in terms of latex, which was virtually absent after either treatment. Calcium chloride was not used at the request of the grower for certification reasons. This treatment is used to control grey spot, which still is a problem although now much less significant of this variety.

After another selection process, the fruit was packed according to protocol except that 75% of the boxes had only 17 kg of fruit rather than the conventional 18.9 kg. This alteration was made because the curvature of the 'Mona Lisa' was so severe that the heavier weight did not allow the proper placement of the box cover without too much contact with the top bunches. Half of each pallet was packed in a plastic mesh to help differentiate the product and address the finger-drop problem. All other packing and shipping protocol was followed.

The shipment arrived in Ottawa on 20 May at 10 am after 8 days of travel with a temperature upon arrival of 15.3°C. The temperature through the trip could not be determined because the Ryan recorder had been stolen.

In Ottawa, at 1 pm the pallets were placed in a nonpressurized ripening room set to deliver half the normal doses of ethylene used for 'Cavendish'. After 18 hours, the room was ventilated. One half pallet was placed in a warmer room for use in consumer demonstrations, one half remained in the room at 14.4°C waiting for delivery at stage 2 on May 22 and 23, one full pallet was stored at 13.3°C for the second week. At retail, on May 23 and 24, retailers did not store the fruit in the cold room according to protocol so that ripening would be further encouraged.

The fruit in the second pallet, which was held at 13.3°C was distributed on Tuesday 2 June. Cases of product were distributed to two mainstream supermarket outlets and three natural food stores (Table 3). Postharvest data collection was directed by a qualified postharvest scientist from the University of Costa Rica and consumer data was collected on the weekend of 23 and 24 May at each of the stores through an intercept survey. A brief profile of participating stores is presented in Table 3.

Postharvest Results of Second Trials

The results of the trial (Table 4) successfully met the postharvest goals set for it (Saenz 1998b). These included:

- First, testing the improvements made with respect to quality in terms of physical damages (insect, mechanical), red spot, grey spot, separation of hands, latex production, and weak necks through random sampling of cases throughout the trial after arrival to Canada and formal quality evaluations (total of 12).
- Second, evaluation of shelf life through to retail under controlled ripening and distribution conditions outlined in recommended protocol through continual close monitoring and documentation by the specialist from the University of Costa Rica as well as a randomly selected test case that was put aside from the second week pallet at ambient temperature and monitored.
- Further comments are given in Appendix 7.

Table 4. Results of postharvest second trial.

Table 3. Profile of participating stores.

Store type	% Of produce section that is organic	Is organic produce integrated?	Number of organic fruits	Number of organic vegetables
Conventional 01	ca 2	no	4	16
Conventional 02	ca 2	no	6	13
Natural/Health Food Store 01	100	no	6	25
Natural/Health Food Store 02	ca 2	yes	4	4
Natural/Health Food Store 03	100	no	15	50

[a] Based on linear measure.

Fruit quality

Variable in terms of size — many boxes had some very small fruit; fullness of the fruit varied within each box; physical damage due to insect damage and handling was minimal;

Many fruit found with red spot located at the contact points between fingers of the same hand; however, red spot frequency was much reduced from the first trials;

Grey spot present but also much reduced;

Separation of hands, while not a problem in Canada because deformed bunches are selected out at the packing house, represents a considerable problem at the packing house by creating a high rejection rate; further, separation of the fingers combined with heavy curvature necessitates a taller box for shipments of fruit at the standard weight of 40 lb (18.1 kg);

Latex scars were not evident indicating the problem of latex had been solved adequately through the longer washing time;

Finger drop was not a problem with necks of the fruit remaining strong until stage 7. The use of the netting to address finger drop was not necessary;

The net used for some of the fruit showed some disadvantages — first, it increased the surface damage and, second, the color contrast was not attractive as this made the bananas look more yellow than they actually were; an advantage, however, was that the net helped to differentiate the product from the conventional bananas;

Overall fruit quality was very good.

Shelf life

The yellow life and shelf life, with the implementation of the proper protocol, was closer to that of the 'Cavendish'. If properly handled and gassed, the fruit has a good (4–5) days of yellow life.

Over all

Sales were better than expected — in one of the stores that carries organic bananas, the 'Mona Lisa' were priced lower than the alternative organic bananas, so this may have contributed to increase the sales; on the other hand, one of the big supermarkets sold almost all their 'Mona Lisa' bananas.

Market Test and Intercept Survey

The third goal of the trials — to investigate consumer acceptance of the 'Mona Lisa' banana — was filled through the implementation of a consumer intercept survey. To gauge consumer acceptance, interviewers were placed at each of the five participating stores collecting information while offering complimentary samples. The survey instrument required about 3 to 4 minutes of the consumer's time and was fashioned to maximize information collection (Appendix 8) .

Survey results

The following survey results represent indicators of consumer acceptance to the 'Mona Lisa' based on several product characteristics. Results at an aggregate level contrast consumers of main-stream supermarkets with those of smaller natural or health-food stores. Table 5 summarized some important behaviours and characteristics that came out of this analysis (elaborated from Gussman 1998).

Table 5. Summary of results of in-store consumer interviews.

"Certified organic" product was considered a product strength by nearly all participants

Large majorities enjoyed the taste of the product; of those who said they would definitely or very likely buy the 'Mona Lisa' in their future shopping, many (78%) indicated that taste was a strength

Although "size" was viewed as a relative strength by the largest numbers of respondents, it also was considered a weakness by the largest groups

Just over half of all respondents were willing to pay up to 0.99 CAD/lb (2.18 CAD/kg)

When asked which characteristic is the biggest perceived weakness, 68% from conventional stores and 64% from alternative stores indicated it was the price; of those stating price was the biggest weakness, 18% said they would definitely buy the product next time and 11% said it was highly likely; of those in the survey who have bought organic bananas in the past 6 months and of those who said they would definitely or very likely buy the 'Mona Lisa' in their future shopping, all groups showed less price sensitivity and tended to be located in natural and health food stores

Awareness indices of organic bananas reveal that much larger proportions of those at alternative stores had heard of (53.4%), seen (55.8%), and bought (37.4%) organic bananas than had shoppers sampled at the two conventional stores

Environmental reasons appeal to the largest base of consumers — over 90% overall

Product-related attributes such as "slower to brown when peeled" and "thick skinned" appealed to similar — and large — proportions of consumers. According to twice as many conventional store shoppers, these two characteristics were the product's "biggest strength"

The name 'Mona Lisa' was considered a strength by only modest numbers (just over 25% of both samples)

Policy or political reasons for product purchase tended to be a strength for more consumers at alternative stores. Of the two, "helps small farmers" was considered a relative strength by about 80% of those asked. Mention of the Canadian government research support, on the other hand, was listed as the single biggest weakness of the product by 37% of conventional stores and 22% of alternative-store consumers.

Synopsis of market information survey

The intercept survey allowed us to draw some interesting conclusions about the 'Mona Lisa' from which we can extrapolate three points to be used for future market strategy. In marketing, messages must be simple and be used to differentiate a product from the others. A strategy of differentiation builds on the most important qualities the target consumer perceives about the product. In the case of the 'Mona Lisa', whether in a conventional or health food store, the fruit must be differentiated first as "certified organic." Second, but also important, taste specifically in the case of the 'Mona Lisa' is a product strength and would be a good differentiator. Of all those surveyed, 32% indicated that taste was the product's biggest strength. And of those that said they would "definitely" or "most likely" buy the product, 78% saw taste as a strength. Finally, regarding price, it is clear that some consumers will not pay 0.99 CAD/lb even though this is very competitively priced for an organic bananas. However, a majority in both conventional and natural food stores, said they would be willing to pay up to 0.99 CAD/lb for the product. It would then seem important for market expansion to maintain the price below the 1 dollar mark. Taken together, a focus on all these three strategic messages combined with high fruit quality seem to be the key for success.

Conclusions

We have seen in this paper that the export banana industry, as part of the world production of bananas, is in dire need of a change toward sustainability. FoodLinks, building on over two decades of IDRC experience within in the field of bananas and plantains, has begun to address these pressing issues through applied research. Because many of the problems of the export banana industry can be attributable to disease, FoodLinks has been working with the FHIA dessert banana varieties that are naturally resistant to such pests to address the problem. The applied research thus far has been in the context of two market trials for a total of 11 shipments of 240 cases. Significant findings in postharvest handling confirm that, in the context of controlled shipments with appropriate handling protocols as indicated in this report, ‘Mona Lisa’ can be successfully brought into the market. The trials also confirm that higher prices than conventional bananas can be achieved with an organic product so that higher value-added should be attainable by growers. This higher value-added provides incentive for producers to adopt this variety. The trials also confirm that consumers rate this variety highly in terms of flavor, size, and “nonbrowning” both in conventional supermarkets and specialty organic stores. In addition, social and environmental benefits derived from this “sustainable” banana increase the attractiveness of the product to the discerning organic consumer.

These experiences indicate areas for further research to promote more-sustainable banana production. More trials must be repeated with larger quantities in other markets. The promotion of sustainable banana production must be done through programs to reach growers and rural associations with credit, technical assistance, and market advice to increase volumes and meet market demands. ‘Mona Lisa’ must also be further promoted in target markets with information on product characteristics, and producer and environmental benefits. Also, farm level cost information must be sought, documented, and distributed so that the financial benefits of organic banana production can be known. And, finally, for those that have adopted these varieties, the effect on incomes and the environment must be monitored and evaluated.

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Abbreviations

BAPIC	Bananas and Plantains Information Centre
CAD	Canadian dollars
CALAC	Carribean and Latin American Congress
CATIE	Centro Agronómico Tropical de Investigaciones y Enseñanza
CD-ROM	compact disk–read-only memory

CEPAL	United Nations Economic Commission for Latin America
CNPA	Canadian Natural Products Association
CORBANA	Corporación Bananera Nacional
EPA	US Environmental Protection Agency
FHIA	Fundación Hondureña de Investigación Agrícola (Honduran Foundation for Agricultural Research)
FUNDAGRO	Fundación para el Desarrollo Agropecuario
IDRC	International Development Research Centre
IDRIS	Inter-Agency Development Research Information Service
INIBAP	International Network for the Improvement of Bananas and Plantains
INIBAP/LAC	Scientific Committee of the regional network of the International Network for the Improvement of Bananas and Plantains (INIBAP) for the countries of Latin America and the Caribbean (LAC)
IRAZ	Institute de Recherche Agronomique et Zootechnique
IUCN	International Union for the Conservation of Nature and Natural Resources
JKUAT	Jomo Kenyatta University of Agriculture and Technology
LAC	countries of Latin America and the Caribbean
MGIS	*Musa* Germplasm Information System
PANNA	Pesticide Action Network North America
PESTIS	Pesticide Information Service
NARS	national agricultural research system
NGO	nongovernmental organization
TNC	transnational corporation
UBEP	Union of Banana Exporting Countries
USD	United States dollars
WINBAN	Windward Islands Bananas

Appendices

1 — Selection of IDRC's Banana-related Projects, 1971–1998

The descriptions given here are based on the project summaries at the time the projects were initiated.

1. Osmotic Dehydration of Bananas, 1971

The introduction of dried bananas for human consumption has been met with great acceptance; drying bananas through osmosis has proven to be safe, efficient, and effective. The University of the West Indies proposes to apply the results of previous research undertaken at the Food Research Institute of Canada using freshly harvested produce in Trinidad and working in cooperation with small local industries.

2. Cropping Systems (WINBAN) — Phase I, 1977; Phase II, 1980

Research undertaken to improve cropping systems in the Windward Islands has shown the possibility of growing cowpeas, maize, and sweet potatoes in interrows of bananas (the main crop of the island) soon after banana planting. The only negative effect on banana production is a delay of 15–34 days in banana fruit production. This project will evaluate existing farming practices and introduce varieties (maize, cowpeas, and plantains) for intercropping with bananas to improve agricultural production.

Phase II will further develop and demonstrate the most promising intercropping systems, which include peanuts, sweet potatoes, dasheen, maize, and tannia; introduce grain legumes such as cowpeas, mung beans, or groundnuts to create new cropping patterns; and continue to study the effects of intercrops on the plantain and banana production.

3. Plantains (Cameroon) — Phase I , 1978; Phase II, 1983

Plantains are an important food crop traditionally grown in shifting agriculture patterns throughout the rain forest zone of Cameroon. The objectives of this project are to select plantain cultivars for stable yield and for disease-, pest-, and storm-resistance; to develop improved agronomic practices for plantains; and to train researchers in plantain and associated crop research.

The general objective of phase II is to develop improved cultivars, agronomic techniques and marketing systems for small-scale producers of plantains, bananas and associated crops.

4. Legumes Under Bananas (Union of Banana Exporting Countries), 1979

Nitrogen is an important factor in the production of bananas and plantains, which are important food crops in most tropical developing countries. Because of intense rainfall, banana plantations are affected by erosion and loss of nutrients, and nitrogen loss can be high in tropical soils that are not adequately protected by vegetation. Tropical legumes species, which have the capability of fixing atmospheric nitrogen through *Rhizobium* bacteria, will be introduced as a cover crop in banana plantations. The project will evaluate soil–tropical legume–*Rhizobium* relationships, study the influence of selected legumes upon weed control, and select optimum combinations of legumes and *Rhizobium* for maximum nitrogen fixation.

5. Banana Processing (Union of Banana Exporting Countries), 1980

Although the banana industry in Central America provides a major source of export revenues, few benefits accrue to small producers. About 15–20% of the banana crop, which does not meet the export standards dictated by foreign markets, is wasted. This project will develop a rural banana-processing industry to produce low-cost food products using downgraded bananas — such as banana cake, puree, chips, beer, and so forth — for the benefit of rural producers and consumers.

6. Bananas (Philippines) — Phase I , 1982; Phase II, 1987; Phase III, 1990

The objectives of this project are to promote an increased production and utilization of the nonexport banana varieties as a new source of economic livelihood for small-scale growers and small- to medium-scale processors; develop and adapt technologies that will facilitate the dissemination and free exchange of banana germplasm throughout the tropics; evaluate the field performance of promising banana cultivars under different growing conditions; and improve and develop cultural and management practices for commercially acceptable banana cultivars appropriate to small-scale producers.

In Phase I of this project, research on tissue culture and leaf-disease screening was successful, but cultivar evaluation and banana-cropping systems work was not as successful. This second phase project will supply disease-free material to farmers, develop virus-detection systems using monoclonal antibodies, screen cultivars for leaf diseases, study Bugtok disease, and explore tissue-culture germplasm storage and banana breeding. This research will be an important part of the International Network for the Improvement of Bananas and Plantains.

Previous phases (I and II) of this project yielded techniques and methodologies for mass propagation of virus-free plants, and the development of monoclonal antibodies to detect the presence of viruses. Other activities included screening techniques for important leaf diseases of bananas and the maintenance of a germplasm collection with accessions from most Asian countries. Phase III will build on and fine tune results from previous phases. It contains a major on-farm demonstration component.

7. Plantain / Banana Improvement (Jamaica), 1982

The serious situation caused by the spread of black Sigatoka disease (a fungal disease) through Central America and part of West Africa is threatening the staple plantain and banana food supplies of many small holders. This project will provide urgent assistance to the Jamaica Banana Breeding Scheme to enable it to maintain its germ-plasm collection and to carry out a modest breeding program until a full-scale breeding program can be restarted; and it will enable a start to be made in developing a facility for plantain and banana meristem culture that will allow material to be imported and exported without the risk of disease transmission.

8. Livestock Feeding Systems (Philippines), 1982

This project will evaluate ways in which banana stems, leaves, and suckers can be supplemented with other crop by-products so that the relatively isolated hillside farmers can satisfy the feed requirements for finishing growth of backyard cattle or water buffalo.

9. Bananas and Plantains Information Centre (BAPIC), 1983

The goal of this project is to enable the Union of Banana Exporting Countries to extend and expand its Banana and Plantain Information Service for member countries and the rest of the world. The project will extend and increase services already begun and develop them to service a world clientele, by providing such outputs as a quarterly abstract bulletin, a directory of research workers, literature reviews, and special bibliographies supported by a photocopy service.

10. Agro-Exports (Ecuador), 1983

This project will examine the regional economy of Ecuador's southern coastal region, a zone that produces nearly all of the country's bananas for export and much of its cocoa. Researchers will analyze the marketing system for bananas and for cocoa, and the means by which prices and production quotas are determined; study the contractual arrangements and technical assistance offered by banana exporters to local producers; study the income and living conditions of agricultural labourers; and suggest alternative marketing structures, contractual agreements, and pricing policies for banana and cocoa industries.

11. Banana Processing (Honduras), 1984

Bananas that do not meet export standards in Honduras could be used in banana-based food products. The purpose of this project is to determine the feasibility of establishing a banana-processing plant at a rural banana cooperative. Researchers will establish appropriate ripening procedures for green bananas to ensure good quality products; establish processing procedures to improve the storage life of naturally fermented banana puree; and determine the market potential for banana products.

12. Banana and Plantain Network (INIBAP) — Phase I, 1985; Phase II, 1985; Phase III, 1986; Phase IV, 1988; Phase V, 1989; Phase VI, 1989; Phase VII, 1992

Bananas and plantains are widely grown in developing countries for domestic consumption, yet little research has been done on them. Banana and plantain producers and scientists worldwide have proposed, therefore, that an International Network for the Improvement of Bananas and Plantains (INIBAP) be formed to help support and coordinate research on these crops. The purpose of this project is to support the establishment of INIBAP. The specific objectives of the network are to initiate, encourage, support, conduct, and coordinate research aimed at improving production of bananas and plantains; promote the collection and exchange of information relating to bananas and plantains; and support training for researchers and technicians from developing countries.

The second phase of this project support will permit researchers to exchange improved germ plasm and information, and strengthen their own research programs within the INIBAP.

The third phase of the project will provide continued support to INIBAP in its efforts to strengthen national research programs through the exchange of information and improved germ plasm.

The fourth phase of IDRC support to INIBAP represents the 1988 contribution. IDRC is the Executing Agency representing the donor members pending approval of the INIBAP charter.

The fifth phase grant will provide support for the on-going development of INIBAP. In its strategic plan of October 1988, INIBAP reiterates its main thrust of forging harmonious links, and focusing of germplasm exchange and pathology research, activities most likely to benefit small-scale producers.

Phase six of the project will provide continued support for the development of INIBAP. In its 5-year strategic plan of 1989, INIBAP reiterates its main thrust of forging harmonious links and focusing research on germplasm exchange and pathology research, and thematic activities most likely to benefit artisanal producers.

Since August 1990, INIBAP has had official legal status in France as an international organization, and IDRC has been able to turn over more and more responsibilities to INIBAP itself. The seventh phase of the project will provide final core support for INIBAP.

13. Agro-Exports (Philippines), 1985

The purpose of this project is to study the effect of the pineapple and banana industries on the welfare of local producers and farm labourers. Researchers will examine the bargaining power of different types of producers vis-à-vis the transnationals (TNCs), local producers' access to credit and technology from TNCs and from alternative sources, and the distribution of risk between TNCs and contract producers.

14. Plantain/Banana Improvement (Honduras) — Phase I , 1985; Phase II , 1989; Phase III , 1992

In Honduras, the relatively new black Sigatoka leaf spot disease poses a serious threat to the continued cultivation of plantain. Genetic resistance is the most economical control measure for this disease. The purpose of this project is to upgrade the agronomic qualities of disease-resistant diploids and to breed plantains with resistance to black Sigatoka. Researchers will select promising resistant lines, extract all seeds available in the selected materials, plant seeds, and evaluate seedlings both in the greenhouse and in the field.

Phase two of this project will provide continued support for breeding work on bananas and plantains, to help strengthen efforts to develop resistance to black Sigatoka. New germplasm generated by research activities will be available through International Network for the Improvement of Bananas and Plantains (INIBAP) for wide evaluation.

The third phase of the project will produce improved varieties of plantains and bananas to overcome production constraints among which the black Sigatoka disease is the most important. Support for essential activities to be carried out at the Fundación Hondureña de Investigación Agrícola (FHIA) will be provided. The new improved varieties with a higher yield potential generated by the project activities will be made available through INIBAP for worldwide evaluation.

15. Policy Alternatives for the Banana Industry (Costa Rica), 1985

Bananas account for more than 25% of Costa Rica's exports and are an important source of employment for the rural population and of export earnings for the government. A decline in world banana prices and an increase in the bargaining power of the transnational corporations that handle the government's exports have prompted the government to redefine its short- and long-term policies toward the industry. Researchers will conduct a detailed investigation into the economic and organizational aspects of banana production and marketing with a view to redefining the role of foreign firms, local producers, and government.

16. Banana and Plantain Information Network: Preliminary Phase, 1987; Phase II, 1991

The International Network for the Improvement of Bananas and Plantains (INIBAP) was set up to address concerns over diseases that seriously threaten the existence of these crops. The purpose of this project is to establish information services to support the research work of INIBAP. Project participants will establish an international data base of references on bananas and plantains; produce a bimonthly International Banana and Plantain newsletter; and provide information services to banana and plantain researchers worldwide.

Phase two will concentrate on maintaining and upgrading the existing information system and services, developed during the first phase, and on the decentralization of the information system to the four regional subnetworks in Asia, East Africa, West Africa, and Latin America and the Caribbean. Activities at the regional level will focus on the establishment and the strengthening of regional and national information services, and will include: holding workshops on banana and plantain and on the structure and use of the INIBAP information system; and training regional information coordinators in methodology. At the Headquarters, the program will include: coordination of the activities of the regional networks; upgrading and maintenance of the bibliographic database and generation of the trilingual database of all research information on banana and plantain; production of the INIBAP bibliographic database on CD-ROM (compact disk–read-only memory) for distribution to regional centres; and the production of the international newsletter *MUSARAMA*, international directories, and so on.

17. Bananas/Plantains Somaclonal Mutation (CATIE), 1987

Devastating diseases and pests of plantains and bananas are seriously affecting the income of small-scale growers throughout the tropical world, and the nutrition of people in countries where these crops are a dietary staple. This project will support research to help alleviate these problems by adapting and generating improved methods to promote such useful genetic changes as disease resistance in the genus *Musa*. The work proposed will provide valuable information for the selection and development of new clones of plantains and bananas, which are now endangered.

18. Banana Cropping Systems (Uganda) — Phase I, 1988; Phase II, 1994

Cooked bananas form the staple food of most people in Uganda. However, in recent years the banana crop has been severely affected by introduced diseases and pests, and black Sigatoka disease is now threatening the crop. This project will assist the government to establish a National Banana Research Program, combining the resources of the Research Division with those of Makerere University. Researchers will conduct on-farm research in conjunction with farmers and extension workers in selected banana-growing areas to investigate and find solutions to soil deficiencies and weed, pest, and disease problems of banana-based cropping systems. Researchers will also assemble, classify, and evaluate a collection of banana varieties from both within and outside the country for botanical and agronomic characteristics. Also, they will multiply and distribute planting material of promising banana varieties for further testing under a range of farming conditions and pest and disease hazards.

The overall goal of phase two is to work closely with farmers in the development of technologies and management practices that will permit them to increase the productivity and profitability of their banana-based cropping systems by using safe, sustainable, and environmentally friendly technologies; and stimulate interest and support from key policy institutions.

19. Regional Information Network on Bananas and Plantains in Latin America and the Caribbean, 1989

This project will put in place the information component of the regional network of the International Network for the Improvement of Bananas and Plantains (INIBAP) for the countries of Latin America and the Caribbean (LAC) to develop information services in support of the activities of national research programs. Essentially, the project will establish an information network linking all information activities of the regional research network. It is expected that the project will contribute to the knowledge of all the actors in the banana and plantain production sector, and hence to improvement in the growing, processing, and marketing of these crops in the region. It will also foster regional cooperation in research as well as information activities, and facilitate the function of the INIBAP Regional and Global Research Networks.

20. Latin America Banana Network (INIBAP), 1989; Musa Research Small Grants (Latin America) II, 1994

This grant will provide the Latin American and Caribbean network with a fund to make small research and training awards to foster research in national institutions. The Scientific Committee of the regional network (INIBAP/LAC) of the International Network for the Improvement of Bananas and Plantains (INIBAP) for the countries of Latin America and the Caribbean (LAC) will study the merit of each small grant proposal before approval; and will monitor and evaluate the research process and results.

The previous phase of this project was evaluated as successful and its multiplier effects will continue for several years (for example, positive results of screening of hybrids in Brazil and Venezuela; training of trainers; and technical visits). This second phase will build upon the results of phase one by supporting the less advanced national agricultural research systems (NARS), for example, in Bolivia, Cuba, the Dominican Republic, and the Windward Islands. The project will develop new approaches that increase agricultural productivity and sustainability by using resistant *Musa* germplasm and will provide access to biotechnology tools for the enhancement, dissemination, and conservation of *Musa* biodiversity.

21. Plantain Conservation (Côte d'Ivoire), 1989

One of the most important staple foods in the Côte d'Ivoire is plantain. Estimated losses are about 40%, most occurring at the farm level. This has resulted in the crop being cultivated as a secondary cash crop by farmers. There is a glut during a short period of the year followed by scarcity and higher prices throughout the rest of the year. Considering the rapid increase in population and the lack of foreign exchange to import food, methods of preservation must be developed that will encourage increased production of plantain and reduce losses. This project will determine the efficacy of traditional preservation methods used in the country; develop improved methods of slowing the ripening process; and develop techniques for transforming plantain into a product with a longer shelf life at ambient conditions.

22. Banana Postharvest Technology (Philippines), 1989

The 'Saba' banana is a cooking banana that is grown for domestic use in the Philippines as a vegetable or snack or as a substitute for rice. The objective of this project is to reduce losses of 'Saba' bananas during shipment from the farms to consumption centres. The losses are attributed to immaturity at harvest and high temperatures during transport that hastens the natural metabolic changes producing the green-soft disorder.

23. Mineralization/Nutrient Cycling (Costa Rica), 1990

Bananas require high amounts of mineral nutrients for growth and fruit production. This project will be undertaken in Costa Rica to study the process of mineralization of crop residues in banana and to identify the microorganisms responsible and the major environmental factors affecting the microorganisms activity including cultural practices.

24. Environmental Impact of the Banana Activity in Costa Rica: A Case for the International Water Tribunal 1992, 1991

In February 1992, the Second International Water Tribunal will be held to address environmental problems in the Third World associated with economic activities that are related to water resources management or that negatively affect water resources. Third World nongovernmental organizations (NGOs), with the technical assistance of the International Centre for Water Studies (Amsterdam) and the International Water Tribunal advisors (the Netherlands), will prepare and submit cases. This project will directly support the case preparation of "Environmental Impact of the Banana Activity in Costa Rica" prepared by Fundación Guilombe, a local NGO with close working linkages with researchers from several universities and institutions in Costa Rica. The objectives of the case are to determine the environmental impact of plantation banana production on the aquatic ecosystem of the La Estrella River Basin and the subsequent effects on the people in the region; and to evaluate the legal, economic, social, and political environment in which the banana industry operates with a view to identifying public-policy and plantation-management changes that could reduce the environmental impact associated with the industry.

25. Banana Germplasm Collection (IRAZ), 1991

Bananas are important staple food crops in Burundi and the surrounding region. In recent years, however, several severe diseases and pests have caused considerable crop losses. The International Network for the Improvement of Bananas and Plantains (INIBAP) and the Institute de Recherche Agronomique et Zootechnique (IRAZ), an intergovernmental research agency in Burundi, have been collaborating in collecting, screening, and multiplying germplasm of promising banana varieties. This project will assist IRAZ to establish and maintain the banana collection and trials with necessary supplementary irrigation. Ultimately, the project will increase banana production in Burundi, Rwanda, and Zaire through the improvement of banana-based cropping systems.

26. Shifting Banana Cultivation and Nutrition (Uganda), 1991

Growing of bananas as a dominant food crop has shifted significantly from eastern Uganda to the central and, currently, to southern parts of the country. The socioeconomic consequences of these shifts are largely unknown. This project will study the attitudes of farmers to banana growing in areas formerly dominated by the crop; investigate whether there are alternative economic food crops being grown; and analyze the relationship between banana growing and nutritional status. The study will benefit both policy makers, and health and agriculture extension workers.

27. Musa Germplasm Information System, 1993

The International Network for the Improvement of Bananas and Plantains (INIBAP) will develop an information system and software to coordinate the thousands of accessions that now exist in regional and national collections of banana and plantain (*Musa*) germplasm. The *Musa* Germplasm Information System (MGIS) will contribute to the understanding of the diversity of the two crops, which are staple food sources in many parts of the developing regions of the world, thereby improving research and the provision of healthy planting material to small-scale farmers who are the main producers of the two crops.

28. 'Goldfinger', Cooking Bananas and Plantains: Testing and Dissemination, 1995

Small farmers in two African countries (Ghana and Uganda) will plant elite black Sigatoka-resistant, high-yielding plantain and banana hybrids; in Honduras, where the improved varieties were developed, the project will monitor and evaluate the testing and dissemination process already under way. The project will improve the food security of the participating countries by bringing back plantain and banana productivity levels to the point where they were before the appearance of black Sigatoka with the concomitant increase in production and improved fruit quality.

30. Tissue Culture Banana for Smallholders (Kenya), 1996

This project will pilot test the process of sourcing selected banana planting materials, multiplying them by tissue culture at the Jomo Kenyatta University of Agriculture and Technology (JKUAT), and adapting, promoting and distributing the final planting material to selected farmers in three banana-growing areas of Kenya. The objective is to assess the feasibility, cost-effectiveness, and potential benefits of conducting such an enterprise on a commercial basis under Kenyan conditions.

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3 — Profile of Fungicides used in Control of Black Sigatoka

Toxicological effects	Ecological effects	Notes
Mancozeb (Dithane)		
In spray form, moderately irritating to skin and respiratory mucous membranes Potential to cause goitre, and has produced birth defects and cancer in experimental animals	Slightly toxic to birds on an acute basis Highly poisonous to warm-water fish and at least moderately toxic to cold-water fish Harmful to wildlife	Agricultural workers have developed sensitization rashes A metabolite of Mancozeb (ETU) has been classified as a probable human carcinogen by the US Environmental Protection Agency (EPA) Has potential for leaching into groundwater
Benlate (Benomyl)		
Skin reactions seen in rats, guinea pigs and humans Can cause birth defects in test animals Classified by the EPA as a possible human carcinogen	Moderately toxic to birds Variably toxic to fish Substantially reduces some soil dwelling organisms	
Cholothalonil (Bravo)		
Slightly toxic to mammals Very high doses may cause many symptoms including death High degree of human eye and skin irritation Potential human carcinogen Toxic to kidney	Highly toxic to fish, aquatic invertebrates, and marine organisms	Found in local water supplies near Valle del Estrella from banana plantations (Foro Emaus 1998, p. 6)
Tridemorph (Calaxin)		
Harmful by inhalation, in contact with skin, and if swallowed		
Propiconazole (Tilt)		
Acute exposure may result in irritation of eye, skin or respiratory tract May cause headache, dizziness, and anaesthesia Produced increased liver tumors in test mice	Slightly toxic to fish and wildlife	Found in Rio Suerte basin draining into the Tortuguero conservation area (Foro Emaus 1998, p. 6)

Sources:
Benlate — Extoxnet (1994b)
Cholothalonil — Extoxnet (1994a)
Mancozeb — Extoxnet (1993)
Propiconazole — Environmental Health Data Search (1991)
Tridemorph — Worksafe Australia (1996)

References:

Environmental Health Data Search, Deervale Road, via Dorringo, NSW 2453, Australia. *At* <ftp://alternatives.com/library/envchem/propican.txt>

Extoxnet. Extension Toxicology Network database maintained by the National Agricultural Pesticide Impact Program, a cooperative effort by the University of California–Davis and other US universities. *At* <http://ace.ace.orst.edu/info/extoxnet/ghindex.html>

Foro Emaus. 1998. The price of bananas: the banana industry in Costa Rica. Global Pesticide Campaigner, 8(1), 3–7. (Pesticide Action Network North America, San Francisco, CA, USA.)

Worksafe Australia. The Australian Hazardous Substances database maintained by the National Occupational Health and Safety Commission, Australia. *At* <http://www.allette.com.au/worksafe/wsa>

4 — FoodLinks Mission Statement and Objectives

Mission Statement

FoodLinks will create partnerships among food producers, processors and marketers in developing countries and the North through the provision of commercial liaison and project management services, training and research support, leading to increased capacity, employment and incomes for developing country communities in a sustainable and equitable manner.

Objectives

Overall

FoodLinks' goal is to generate and broker knowledge, strengthen research and development capacity in the agrifood enterprise field, and to facilitate the implementation of a range of market-oriented strategies in the agrifood sector that support sustainable development.

Specific

A. To support research, testing, evaluation, documentation and training related to FoodLinks experiences that support equitable and environmentally sound development for small producers in Southern countries that contribute to understanding of the role of market forces and public–private partnerships as vehicles for sustainable development.

B. To support a range of activities in market and product research and development which lead to identification of novel agrifood products, processes and business opportunities involving small producers in Southern countries in mutually benefitting partnerships with Northern country agrifood enterprises as well as local companies in the South.

C. To promote the use of information and communication networks in facilitating food product and market development and the discussion and dissemination of methodology, results, and lessons learned.

D. To expand the resources of FoodLinks through collaboration with other donors and private sector partners, and to develop its capacity and strength as a commercial entity within a secretariat model.

5 — Postharvest Research at University of Costa Rica

Preliminary Observations of the Ripening Behaviour of 'Mona Lisa' Bananas

Materials and methods

Fruit of 'Mona Lisa' was collected at Ecos del Agro, Guapiles, Costa Rica. It was harvested between 11 and 12 weeks after the flower assumed a downward position. This means, according to generally accepted banana physiology, that the fruit was at physiological maturity (11 weeks) or just after physiological maturity. The fruit was then transported to the postharvest research laboratory at the University of Costa Rica within 3 hours. The fruit was placed in cardboard boxes using an internal perforated polyethylene liner (standard packing method for North American markets). The fruit was then placed in a cold room at 13.5°C and 90% RH. An air exchange ratio of 12.5% was used.

Fruit was visually evaluated every day until it began to show colour changes evidencing that ripening had started. Colour change was then recorded every day using the standard banana colour chart. A group of fruits in similar degrees of ripeness (according to external colour) was allowed to ripen in a separate cold room. Every day, a uniform subgroup was allowed to reach ambient temperature and 1 hour later placed in 1.5-L jars for respiration measurements. Each jar was equipped with a rubber septum and was sealed after the fruit sample was placed in the jar. A sample of 10 mL of the air in the jar was taken 1 hour after it was sealed and the sample injected into a gas chromatograph (Shimadzu GC14B) equipped with a thermal conductivity detector (TCD) and an Porapak column (Alltech). Measurements of CO_2 were expressed as milligrams per kilogram per hour. Another sample of 10 mL was injected into a gas chromatograph (Perkin Elmer GC-Plus) equipped with an flame ionizing detector (FID) and a molecular sieve column. Ethylene measurements were reported in microlitres per kilogram per hour.

Another group of fruit was evaluated for changes in soluble solids and starch concentration to relate changes in colour, respiration, and internal characteristics.

Results and discussion

Green life of 'Mona Lisa' bananas seems to be shorter than 'Cavendish'. The transport simulation showed that fruit at 11 and 12 weeks of age only had a green life of 4–5 days under cold-room conditions, as compared with 12–15 days for 'Cavendish' fruit. 'Mona Lisa' bananas can start the ripening process after little as 4 days of transport and then reaching stages 5 and 6 within 7–8 days. From a commercial stand point, 'Mona Lisa' has a limitation for long-distance transport, because the fruit can start the ripening process during the transport period, therefore exportation to Europe (10–14 day transport) are difficult at this point. From the production areas in Central America, the obvious markets is North America that is within 4–5 days transport.

The CO_2 production pattern shows that this cultivar is a typically climacteric fruit. This was expected because all the bananas show the same behaviour. However, the peak production of CO_2 is at least 50% higher than the average for 'Cavendish' fruit. Table 1 shows that, under transport temperature, the respiratory peak is reached between stages 3 and 4 (4–5 days of transport) and that this peak represents 260 mg of CO_2 per kilogram per hour, which is relatively high.

Table 1. Carbon dioxide (CO_2) and ethylene (C_2H_4) production by 'Mona Lisa' fruit at different stages of ripening.

Ripening colour*	CO_2		C_2H_4	
	(mg/kg/hr)	SD	(µL/kg/hr)	SD
-1[a]	12	0.95	1	0.12
0	12	1.11	1	0.13
1	25	3.42	10	1.22
2	80	6.78	30	4.33
3	240	19.37	120	16.20
4	260	18.65	80	7.95
5	150	14.55	40	5.26
6	75	8.26	39	3.54

[a] Fruit before reaching physiological maturity.

Table 2. Changes in soluble solids and starch content of 'Mona Lisa' fruit at different stages of ripening.

Ripening colour*	Soluble solids		Starch	
	(Brix)	SD	(% of fresh weight)	SD
-1[a]	1.75	0.35	16	1.22
0	2.15	0.41	15	1.34
1	2.35	0.38	15	1.22
2	3.50	0.47	13	1.06
3	12.16	1.62	9	0.90
4	15.34	2.71	6	0.43
5	19.22	2.92	3	0.17
6	21.68	3.08	2.5	0.18

[a] Fruit before reaching physiological maturity.

The main difference with other banana varieties is in ethylene (C_2H_4) production rate. 'Mona Lisa' reaches a peak of C_2H_4 production at stage 3 at 120 µL of C_2H_4 per kilogram per hour — at least four times higher than reported for 'Cavendish' fruit. Therefore, reports that 'Mona Lisa' tends to ripen faster than 'Cavendish' varieties seem to be correct. Banana fruit, in general, only needs about 1 ppm of C_2H_4 in the air to trigger the ripening process and, in the case of 'Mona Lisa', it is capable of producing enough C_2H_4 for the onset of the ripening process. The C_2H_4 measurements were replicated twice and in all cases the results were similar.

When internal changes were monitored, both the soluble solids and the starch concentration follow a coherent pattern along the different stages of ripening. Soluble solids tend to increase from stage 2 and reach a maximum at stage 6 (Table 2) while the starch is been hydrolyzed into sugars and is decreasing from stage 2 to reach a minimum at stage 6. This pattern is quite normal for bananas with the only difference being the time frame for the changes. Under normal transport conditions and with good quality fruit, ‘Cavendish’ is not going to start these changes until 15 days after harvest whereas ‘Mona Lisa’ starts almost at the time of harvest.

From Table 1, it may be hypothesized that ‘Mona Lisa’ has both a higher C_2H_4 production rate and respiration rate, but also a very short lag period between the time it reaches physiological maturity to the onset of the climacteric rise.

Exploratory Tests to Extend the Postharvest Life of the ‘Mona Lisa’ Bananas

Introduction

From previous work on the ripening behaviour of ‘Mona Lisa’ bananas, it was concluded that the high rates of ethylene (C_2H_4) production and respiration may have a definite influence on reducing the postharvest life of this fruit. So far, ‘Mona Lisa’ has shown fast ripening in the laboratory, and commercial shipments have failed due to accelerated ripening of the fruit.

The main objective of these tests is to extend the green life of ‘Mona Lisa’ fruit by the use of liners to prevent oxygen intake and potassium permanganate to absorb C_2H_4.

Materials and methods

Storage behaviour of ‘Mona Lisa’

Fruits of ‘Mona Lisa’ were collected at Ecos del Agro, Guapiles, Costa Rica, and packed as individual fingers in a display box with a liner of perforated polyethylene (5-mil thickness). The boxes were transported to the postharvest research laboratory at the University of Costa Rica and stored in a cold room at 13.5°C and 90% RH. Every day, each box was evaluated for colour changes, general appearance, latex production, and dehydration or water gain. Evaluations continued until fruit reached stage 6 (according with standard banana colour chart, Dole). The observations were replicated three times 2 weeks apart with different lots of fruit. The results are the average of the three replications.

Preliminary test of potassium permanganate

Fruit of ‘Mona Lisa’ were collected and packed as individual fingers in a display box with a polyethylene liner, four packages of potassium permanganate (PP) adsorbed on a clay matrix (Retarder, Spain) were placed in each box. The liner was then tightly closed. The fruit was evaluated as described in *Storage behaviour*. Three replications were used for both PP and control.

Evaluation of potassium permanganate

Based upon the results of the previous test, doses was adjusted to six packages per box. The fruit was evaluated as in *Storage behaviour* using three replications for PP and control boxes.

Combination liner with potassium permanganate

In this test, different liners were combined with the use of PP. The liners were: high-density unperforated polyethylene, low-density unperforated polyethylene, low-density perforated polyethylene. Tests evaluated as described in *Storage behaviour*. The experiment was set up using three replications of one box each. The results represent the average of two similar experiments.

Results and discussion

Storage behaviour

Our results and the observations made by the grower agree that 'Mona Lisa' is a fast ripening variety. At normal transport temperature, the fruit reached consumption maturity in 7 days of storage. Fruit showed weight loss of 1.05% in the evaluation period, as compared with 0.25% for 'Cavendish' bananas in previous tests. Latex problems were severe, both in the degree of darkening and in the amount of latex deposited in the bottom of the box. Crown rot problems were found and the fungi *Fusarium roseum* and *Collectotrichum gloesporioides* are the causal agents. Fruit ripening was uneven in the same box, evidence of inappropriate harvest.

Preliminary test of potassium permanganate

The RETARDER commercial brand was selected because is a good quality product and is easy obtain in Costa Rica: in some preliminary tests in our laboratory, it has shown good effect on reducing the ripening speed. The use of four packages of 7 g each reduced the rate of ripening. Fruit treated with PP needed 24 days to reach stage 4, as compared with control fruit that required only 10 days. The fruit used for the test was relatively young (9 weeks hanging), and this could have had an influence in the extended life of the fruit. Crown rot and latex problems were detected.

Evaluation of potassium permanganate to reduce ripening rate

In a second test, the use of six packages of 7 g each showed that the effectiveness of PP in delaying the ripening process was significant. Treated fruit reached stage 2 of ripeness 24 days after harvest, whereas control fruit reached stage 7 in 10 days.

Control fruit showed the uneven ripening described before, but after 10 days of storage all the fruits in the same box reached stage 7. In the treated boxes, some fruits start to change colour but the presence of PP minimized the effect of their C_2H_4 production on the rest of the fruit. The use of six packages of PP gave adequate control of ripening plus a safety margin.

However, results should be taken carefully because a commercial shipment may have a different behaviour because of the high volume of fruit in a confined space.

Combination liner with potassium permanganate

The use of unperforated liners has an advantage over the perforated ones for green life. The treatments that included PP had a slower ripening rate. The use of liners made of high-density polyethylene showed better green life. The combination of high-density unperforated liner and PP seems to be a valid option for 'Mona Lisa' bananas; however, fruit from this treatment had difficulties to ripen without the use of external C_2H_4.

Storage of ‘Mona Lisa’ Bananas at Subnormal Temperatures

Introduction

Most of the commercially grown bananas derive from varieties or lines of tropical origin. In general, ‘Cavendish’ group varieties are highly susceptible to low temperatures, and under certain condition may show signs of chilling injury. As a result, most international transport and commerce of bananas is made at the generally accepted temperature of 13.5°C that has been shown over the years to be safe and cold enough to preserve the quality of packed fruit. Almost all the available literature states that, at temperatures below 13.5°C, the fruit suffers vascular oxidation, off-colour of the pulp, pitting, and even inability to ripen. In general, colour changes in banana fruit are due to the action of polyphenoloxidase that acts on the phenolic compounds that are abundant in both peel and flesh of the commercially grown bananas. Clearly, this kind of damage affects the quality and marketability of the fruit and therefore much care is taken during transport and storage to avoid low temperature damage, although the fruit are able to respire and even ripen at this temperature. In part, to overcome the problem of ripening during transport at 13.5°C, most modern cultivars were selected taking account of the long trips and the risk of ripening, so most of them have a long lag between reaching physiological maturity and the onset of the climacteric rise: in other words, they have a genetic delay between harvest and the trigger of ripening.

‘Mona Lisa’ tends to ripen quite fast and in a nonuniform fashion. However, it has a lower rate of oxidation. The fast ripening process, and the low oxidation of the fruit, lead us to believe that the use of temperatures below 13.5°C could represent an advantage in maintaining the quality and retarding the ripening of the fruit.

Materials and methods

‘Mona Lisa’ fruit were harvested and treated according to the Ecos del Agro procedures. The boxes were standard size and shape for bananas. A liner of low-density polyethylene of the open tubular type was placed in the box. The packed fruit were transported to the postharvest research laboratory at the University of Costa Rica.

The boxes were weighed, inspected for general quality and then divided into groups of boxes: each group representing a storage treatment (Table 3).

Storage time was scheduled to be 1, 2, or 3 weeks. Each treatment was evaluated for chilling damage in both peel (Table 4) and pulp.

Chilling damage was evaluated both upon removal from the cold room and after 24 hours at ambient conditions (with the objective of letting the symptoms develop). A sample of fruits were separated for electrolyte-leakage assessment. Disks (10 mm in diameter and 3 mm thickness) were cut from the peel, weighed, and washed three times with deionized water. The disks were placed in a test tube and 20 mL of a solution of 0.3 molar sorbitol was added to each tube. After constant agitation for 3 hours, the supernatant was measured for electrical conductivity using a conductivity bridge (Omega CM-70) equipped with a conductivity cell with platinum electrodes. After the first reading, the disks and sorbitol were frozen overnight to -20°C. The following day, the samples were thawed and another reading was made. With both readings, the total leakage was calculated taking the control and the ambient treatments as references to determine chilling damage. The experimental design used was a completely randomized design with factorial array of treatments (temperature × time) with five replications per treatment: each replication consisted of one box of 18 kg packed in standard boxes.

Table 3. Experimental storage treatments.[a]

Temperature (°C)	Comment
21	Ambient conditions for fast ripening
14	Commercial conditions (control)
11	Moderately low temperature
7	Severely low temperature

[a] In all cases, relative humidity was 85%.

Table 4. Scale used to rate peel damage.

Scale	% of area damaged
0	0
1	0–4.99%
2	5–9.99
3	10–19.99
4	>20

Results and discussion

Storage temperature had a strong effect on the ripening velocity of the fruit (Table 5). At lower temperatures, longer periods were needed to start the ripening whereas fruit in ambient conditions started to show colour change as early as the second week. For the 14°C fruit, individual fingers started to show colour development, a pattern that is normal for 'Mona Lisa' and

Table 5. Effect of storage temperatures on ripening stage of 'Mona Lisa' bananas.

Storage time (weeks)	Storage conditions			
	Ambient	14°C	11°C	7°C
0	0.0a	0.3a	0.0a	0.0a
1	0.4a	0.3a	0.0a	0.05a
2	2.0a	1.0b	0.8a	0.2c
3	5.5a	1.45b	1.0b	1.0b

Note: Within a column, values followed by different letters differ significantly ($P = 0.05$).

Table 6. Effect of storage temperatures on chilling injury of 'Mona Lisa' bananas.

Storage time (weeks)	Storage conditions			
	Ambient	14°C	11°C	7°C
0	0a	0a	0a	0a
1	0a	0a	0a	0a
2	0b	0b	0.45a	0.65a
3	0c	0c	1.7b	2.8a

Note: Within a column, values followed by different letters differ significantly ($P = 0.05$).

Table 7. Effect of storage temperature on percentage of normal ripening of 'Mona Lisa' bananas

Storage time (weeks)	Storage conditions			
	Ambient	14°C	11°C	7°C
0	100	100	100	100
1	100	100	100	95
2	100	100	100	80
3	100	100	100	67

Note: Within a column, values followed by different letters differ significantly (*P* = 0.05).

Table 8. Effect of storage temperature on electrolyte leakage (% per hour) of peel of 'Mona Lisa' banana.

Storage time (weeks)	Storage conditions			
	Ambient	14°C	11°C	7°C
0	5.1a	5.1a	5.1a	5.1a
1	5.65ab	7.1a	5.25ab	4.15b
2	6.1b	11.6ab	9.05b	13.85a
3	14.15b	11.0b	15.12ab	18.23a

Note: Within a column, values followed by different letters differ significantly (*P* = 0.05).

eventually leads to full box ripening; however, fruit at 11°C and 7°C avoided the uneven ripening.

After the first week of storage, no symptoms of chilling injury as observed at the time of removal from the cold room were detected in any treatment (Table 6). For the second week, treatments at 11°C and 7°C showed some slight damage at peel level but not in the pulp. For the third week, fruit stored at 11°C showed moderate symptoms (1.7 in the defined scale) and the 7°C fruit showed severe damage (2.8 of the scale). In no case were pulp symptoms observed.

With evaluation 24 hours after removal from the cold room, there were no increases on the chilling injury symptoms already present in the fruit at the time of removal. No new symptoms developed.

Storage temperature did not alter the normal ripening pattern at ambient, 14°C, or 11°C temperatures (Table 7). However, fruit stored at 7°C ripened normally but showed peel darkening that affected visual quality of the fruit. Sensory panel evaluation did not show any difference among fruit pulps from different treatments.

The electrolyte leakage evaluation (Table 8) reveals that, at 3 weeks storage, there were differences among the treatments stored at 14°C and 11°C as compared with fruit stored at 7°C. Fruit stored at ambient conditions showed high levels of electrolyte leakage but this was due to a more advanced ripening process.

Preliminary Tests on the Commercial Ripening of 'Mona Lisa' Bananas

Introduction

From our earlier work, we concluded that 'Mona Lisa' is a fast-ripening variety with high ethylene (C_2H_4) production and respiration rates. Moreover, we found that the green and shelf life of this fruits is short compared with 'Cavendish' and that using C_2H_4 absorbers can extend the green life.

When a market in Canada was identified, it became clear that export without C_2H_4 absorbers would be difficult. However, because of the rapid distribution needed by the Canadian importer, it was also clear that some ripening induction would be necessary.

The objective of these preliminary tests was to give some general ideas of how to ripen 'Mona Lisa' bananas. However, it does not pretend to be a ripening guide because conditions of temperature, humidity, and so forth are quite different in Costa Rica and the final market. This is merely a starting point from which the importer may start his own tests.

Materials and methods

'Mona Lisa' fruit was collected at Ecos del Agro, Guapiles, Costa Rica, and transported within 3 hours to the postharvest research laboratory at the University of Costa Rica. The fruit arrived already packed in cardboard boxes of the regular banana type with a tubular polyethylene liner open at the top. Four packages of potassium permanganate (RETARDER, Spain) were included in each box. The fruit was 12 weeks of age. The fruit was then placed into a cold room at 13.5°C and 90% RH to simulate the transit period to the Canadian market (5 days). After the transport simulation, the fruit was evaluated for colour changes and stage of ripeness. The fruit was moved to a ripening room (forced air at 13.3°C or 15.5°C and 90% RH) and C_2H_4 was provided by a catalytic generator (Arco, Inc) with the selector adjusted to deliver either the commercial dose (between 100 and 125 ppm of C_2H_4 constant for a 24-hour cycle) or half the commercial dose (same concentration but for a 12-hour cycle). Once treated, the ripening room was ventilated to eliminate the remaining C_2H_4 and the fruit allowed to ripen. The numbers of days to reach stage 4 and the number of days of shelf life were recorded, some observations about fruit quality in a informal panel were also included. The experiment was set up as a completely randomized design using five replications of each treatment — each replication consisted of one box of bananas packed in standard boxes with perforated polyethylene liner.

Results and discussion

Fruit placed into a room with a normal C_2H_4 cycle required 4 days to reach stage 5 regardless of the temperature (Table 9). The fruit pulp was described as sticky by the panel, and showed some alteration of the pulp structure. The fruit treated with half doses of C_2H_4 required 5 days to reach stage 4 and the pulp was judged as normal. Control fruit required about 7 days and the pulp was also normal. It seems that the temperature has little effect on the colour changes of the peel and internal characteristics. However, it does have a moderate effect on the ripening rate: fruit ripened at 13.3°C required only a few hours more to reach the same external colour.

The shelf life of the fruit stored at 13.3°C (Table 10) was influenced by the ripening treatment, fruit treated with normal C_2H_4 doses showed a shelf life of 3 days, whereas fruit ripened under half doses showed 4.25 days of shelf life, the control exhibited a short life of

2.6 days. The difference among treatments is statistically significant (0.05%). Storage at 15.5°C had a similar effect on shelf life. Fruit ripened at 15.6°C showed a similar behaviour but the shelf life was slightly shorter than for the fruit at 13.3°C.

The soluble solids concentration of the fruit was influenced by the treatment. Control fruit developed low soluble solids concentration (16%). The treatment in the normal C_2H_4 cycle showed a slightly better concentration (17.25%). Higher soluble solids (20%) were obtained with the use of half of the commercial doses.

The temperature seems to have only a marginal effect on the green life, the shelf life, and the soluble solids concentration of 'Mona Lisa' fruit. The 13.3°C treatment showed generally better commercial behaviour than 15.6°C. It is possible that, due to the naturally fast ripening process of the 'Mona Lisa' fruit, it may benefit from lower temperature and C_2H_4 doses because

Table 9. Effect of ethylene treatment at 15.5°C or 13.3°C on ripening of 'Mona Lisa' bananas.

Replicate	Days to ripen from stage 0 to 5					
	Treatment at 15.5°C			Treatment at 13.3°C		
	Normal cycle	Half cycle	Control	Normal cycle	Half cycle	Control
1	4	5	6	4	5	7
2	4	5	6	4	5.5	7
3	4	5	7	4	5.5	7
4	3	5.5	8	4.5	5.5	8
5	4	5	7	4.5	6	7
Average	3.8b	5.1ab	6.8a	4.2b	5.5b	7.2a

Note: Within a temperature treatment, values followed by different letters differ significantly (P = 0.05.)

Table 10. Effect of ethylene treatment at 15.5°C or 13.3°C on the shelf life of 'Mona Lisa' bananas.

Replicate	Days of shelf life at ambient temperature					
	Treatment at 15.5°C			Treatment at 13.3°C		
	Normal cycle	Half cycle	Control	Normal cycle	Half cycle	Control
1	2.5	4	2	3.5	4	3
2	2.5	4	2	3	4	2.5
3	3.5	4	3	2.5	4.5	3
4	3	3.5	2	3	4.25	2
5	3	4	2.5	3	4.5	2.5
Average	2.9b	3.9a	2.3b	3.0b	4.25a	2.6b

Note: Within a temperature treatment, values followed by different letters differ significantly (P = 0.05.)

the ripening process is slowed and more acceptable characteristics can be obtained.

Latex Control in 'Mona Lisa' Bananas

Introduction

One of the characteristics of 'Mona Lisa' is an abundant production of latex. Once the bunch is separated from the plant, much care has to be exercised to prevent latex coming in contact with the fruit. Latex of 'Mona Lisa' seems to be thicker and darker than the latex of 'Cavendish'. No chemical analysis has been performed yet, but the amount of latex is greater than from 'Cavendish' fruit. Even with standard banana packing-house operations that allow for a 10-minute period in a water tank with detergent to allow all the latex to flow out of the fruit, 'Mona Lisa' continues to produce a considerable amount of latex once in the transport process. Reports from Canada mentioned that latex spots are a major constraint for the commercialization of this fruit.

Because this variety is intended for organic production, normal 'Cavendish' treatments cannot be used. For example, in Costa Rica, most of the banana operations use an artificial soap (alkyl-aril-sodium sulfonate) that is effective in solubilizing the latex and keeping it in the water tank. Therefore, once the fruit is rinsed, the soap and the latex are eliminated. Most of the organizations that certify organic produce stated that the only acceptable treatment is the use of potassium-based soaps; however, no potassium soaps that can remove the latex from 'Mona Lisa' are commercially available.

Recently, a Costa Rican company named Quinagro began to produce an insecticide based on the ethanol solution of an organic potassium soap, and have an experimental formulation of the soap in a water base. However, no evaluations have been performed with bananas.

The aim of this experiment is to reduce the amount of latex that accumulates on the surface of the fruit and to reduce the in-transit production of latex.

Materials and methods

Estimation of in-transit latex production

For this estimation, the control fruit of the previous experiments were evaluated for an additional variable. Once washed and packed, the fruit was placed in cold room at 14°C and stored for the period. At the end of the transport simulation, the internal liner was retrieved from the box, allowed to dry, and then weighed. This weight was compared with the initial (before packing) weight. The difference was considered as the dry latex that accumulated in the liner.

Effect of washing time on in-transit latex accumulation

A crown trimming was performed to 12 lots of 10 freshly harvested 'Mona Lisa' banana clusters to eliminate the dry tissue and allow the latex to flow. Each group was placed in a 20-L water tank and the latex allowed to drain for 0, 5, 10, or 15 minutes. The fruit was then packed in standard boxes with a polyethylene liner. All the fruit was placed in a cold room at 14°C and 85% RH to simulate a 10-day transport period. At the end of the transport simulation, the liners were retrieved from the boxes, allowed to dry, and then weighed. This weight was compared with the initial (before packing) weight to estimate latex accumulation. Four replications for each washing treatment were used.

Treatments to prevent latex spots

'Mona Lisa' banana bunches were harvested and clusters separated according to the normal procedure at Ecos del Agro, Costa Rica. The fruit was allowed to drain for a considerable time (45–60 minutes). The fruit was then removed from the water tank, treated with calcium chloride allowed to drain, and then one of three treatments was applied:

- Carnauba wax (Primafresh-31, S.C. Johnson) to seal the crown;
- Potassium-based soap (Organosol, Quinagro, Costa Rica) to remove latex; or
- Control (hand washed with household detergent).

The fruit was then packed in standard banana boxes with a perforated polyethylene liner. The fruit was then stored at 12°C and 85% RH for 10 days, simulating transport to the New

York–Boston area. After the transport simulation, the fruit was evaluated for latex spots and crown appearance. Three replications of each treatment were used.

Results and discussion

Latex production

On average, each box accumulated as much as 7.34 g of dry latex (Table 11). Because the latex of 'Mona Lisa' contains about 85% water, this amount of dry latex represented 48.93 g of fresh latex or about 50 mL. Because the latex of the 'Mona Lisa' banana tends to become dark and jelly-like, this amount gave a bad appearance to the box. In addition to the measured latex, another portion remained on the fruit surface and once dry makes the fruit appear stained and thus decreasing the commercial value.

Effect of washing

Because 'Mona Lisa' is being produced organically, the commercial treatments available to remove latex from 'Cavendish' fruits cannot be used. Therefore, because latex production of

Table 11. Latex accumulation in the internal liner of 'Mona Lisa' banana boxes during a 3-week transport simulation.

Replicate	Weight of latex (g)		
	Clean liner	Used liner	Dry latex
1	15.00	21.73	6.73
2	15.30	21.29	5.99
3	15.20	22.71	7.51
4	14.85	21.18	6.33
5	15.25	23.83	8.58
6	15.35	22.63	7.28
7	15.21	22.45	7.24
8	15.46	22.06	6.60
9	16.04	24.86	8.82
10	15.73	24.08	8.36
Average	15.339	22.682	7.343

Table 12. Effect of washing time on latex production during a 3-week transport simulation of 'Mona Lisa' bananas.

Treatment (minutes)	Latex accumulation (g)
0	7.66a
5	6.82a
10	5.57b
15	4.06c

Note: Values followed by different letters are statistically different (P = 0.05).

‘Mona Lisa’ is more abundant, longer washing periods seems to be the logical option and it did lower the latex production after packing (Table 12). However, even the 15-minute treatment seems to be insufficient to remove all the latex from the fruit and longer periods are advisable.

Latex control treatments

To remove more latex, a potassium soap was used on the fruit surface and crown. The carnauba treatment to the crown was aimed to seal the latex channels and reduce the flow during the transport period. Even control fruit produced a smaller amount of latex than in previous experiments (Table 13). This is probably because a longer washing period was used (over 30 minutes). Therefore, the assumption that longer washing periods may help to reduce the latex problems seems to be correct. Although carnauba wax helped in preventing the latex production, the darkening of the crown, the presence of scales and the dark residues of wax on the fruit surface (resembling latex spots) are undesirable effects. The potassium soap helps to remove part of the surface latex on the fruit (some rubbing was applied as it is usual in Ecos del Agro) and keeps the crown dry and clean. This soap works at Ecos del Agro packing house but, in a previous test in another packing house, there were some problems with white residue. It seems that this soap is very sensitive to water quality, especially hardness (dissolved salts) of the water source.

Table 13. Effect of carnauba wax and potassium soap on latex production and crown appearance in ‘Mona Lisa’ bananas.

Treatment	Latex (g)	Crown appearance
Control	2.33a	dark
Carnauba wax	1.56b	dark
Potassium soap	1.49b	clear

Note: Values followed by different letters are statistically different (P = 0.05).

Protocol for Handling of a Mixed Shipment of ‘Mona Lisa’ and ‘Cavendish’ Bananas to Canada

Introduction

Within the collaboration scheme established by IDRC for the commercial development of the new banana variety FHIA-2 (‘Mona Lisa’) that is tolerant to black Sigatoka, an attempt of a commercial shipment from Costa Rica to Canada will be made. ‘Mona Lisa’ production at the Ecos del Agro orchard in Costa Rica is fully organic, as certified by International Agencies. However, the orchard includes a group of somaclonal mutations that occurred during the tissue culture propagation of the variety. All of them are quite similar to the original FHIA-2 but have differences in ripening pattern and flavour, this mix of genotypes is referred to as ‘Mona Lisa’ here, but must be understood that this is a group of varieties rather than a single one.

Because of the size of the commercial orchard and the availability of fruit, it is impossible to fill a marine container with ‘Mona Lisa’; therefore, the first shipment will be mixed with conventional bananas of the ‘Cavendish’ varieties, produced under normal conditions using chemicals. At least five pallets of ‘Mona Lisa’ will be included in the shipment. The objective of this proposal is to suggest guidelines — based on experience and continuing research — for the handling of the fruit to protect the shipment and ensure the final quality of both groups of fruit.

Harvest

Experience at Ecos del Agro suggests that bunches must be harvested after 12–13 weeks hanging, that is after the flower has emerged and bent down. At this age, the fruit is properly mature, well shaped according to the variety, and able to reach edible maturity. The harvest technique will be conventional for bananas, taking care of avoiding mechanical damage.

Flower removal and separation of hands

In this case, the procedure for ‘Mona Lisa’ is standard for bananas, the removal of the flower reduces the risk of mechanical damage and injuries and also diminishes the risk of contamination with some of the fungi responsible for the crown rot (*Fusarium* and *Collectotrichum*). The separation of hands is also conventional; however, because of the shape of the hands, it is important that enough crown (part of the bunch axis) be left on the hand. This will prevent crown rot, if it appears, from reaching the individual fingers. The hands will be placed in a water tank with continuous water flow to remove latex — it is important that hands be in the tank for at least 15 minutes to remove as much latex as possible. Calcium or sodium hypochlorite (chlorine bleach) at a concentration of 200 ppm is used to reduce the risk of crown rot, concentration of chlorine must be checked frequently because it is inactivated by organic matter such as latex.

Packing

‘Mona Lisa’

‘Mona Lisa’ hands will be packed in standard 42-lb (19-kg) cardboard boxes using an internal liner of polyethylene of the open tubular type. The experience at Ecos del Agro is that an open liner allows air exchange and prevents the accumulation of gel type latex in the bottom of the box. Four packages of 7 g each of potassium permanganate on a porous base (silica, clays, or similar) will be placed in each box — the potassium permanganate oxidizes the ethylene and prevent in-transit ripening thus protecting both ‘Mona Lisa’ and ‘Cavendish’.

‘Cavendish’

‘Cavendish’ fruit will be packed in the standard way for this variety. However, if it does not represent too much of a problem, a bana-vac liner (sealed polyethylene bag) will be used. The intention is to isolate the ‘Cavendish’ from the outside air that may be contaminated with ethylene produced by the ‘Mona Lisa’. The rest of the treatments for latex, crown rot, and so forth, are standard.

Marine transport and container

Fruit will be transported using a refrigerated marine container with a capacity of 20 pallets: of this capacity, at least five pallets will be of ‘Mona Lisa’. Although ‘Mona Lisa’ have been shown to withstand lower temperatures than ‘Cavendish’ without showing any symptoms of chilling injury, because this is going to be a mixed shipment the temperature must be

13.3–14.4ºC, which is safe for ‘Cavendish’. Cylinders of potassium permanganate will be placed in the return duct of the refrigeration system to remove any ethylene produced by the ‘Mona Lisa’, these cylinders will be provided by Universidad de Costa Rica (either RETARDER or ETHYSORB commercial brands). The temperature setting of the container must be checked at every possible step, and pulp temperature should be measured whenever possible. Three temperature recorders (Ryan for instance) will be used: one in a ‘Mona Lisa’ box, one in a ‘Cavendish’ box, and the third for monitoring air temperature. Ventilation slots must be 50% open to allow air exchange with the outside — unless the external temperature is so low that the fruit may be damaged.

Fruit arrival

Upon arrival, ‘Mona Lisa’ fruit must be placed in a room at 20ºC for at least 24 hours to allow the fruit to reach this temperature before ethylene treatment starts because ‘Mona Lisa’ ripens better when the fruit is not too cold.

Fruit ripening

Standard ripening procedures may be adequate for ‘Mona Lisa’. Because a slower ripening will produce better quality fruit, the use of a lower ethylene concentration (for example, 25% of catalytic setting on a 36-hour cycle) will be enough. However, this was done in Costa Rica where conditions are quite different from those in Canada, so this suggestion is merely a reference, and we will have to rely on the operator knowledge and instinct.

After ripening

Once the ripening has been initiated, ‘Mona Lisa’ can reach stage 5 very quickly, therefore, to have enough time for distribution, fruit may be kept at 14–15ºC for up to 1 week. Once ripe and ready to eat ‘Mona Lisa’ fruit has 19–22 Brix, a subacidic flavor with a residue of astringency at the end.

6 — Comparison of 'Mona Lisa' and 'Cavendish' Varieties

'Mona Lisa' bananas	'Cavendish' bananas
Physical characteristics	
Prominent ridges	Smooth ridges
Straighter fingers	More curved fingers
Ripe fruit has a rusty red colour	Ripe fruit is bright yellow
Finger neck is shorter	Finger neck is longer
Finger neck is weaker	Finger neck is stronger
Latex is thicker and darker	Latex is thinner and more transparent
Latex production is high	Latex production is medium
Can withstand temperatures of 11°C	Gets chilling injury below 13°C
Finger is short (average 12.70–15.24 cm)	Finger is longer
Looks like a very young banana	Looks normal
May resemble a small plantain	Looks normal
Internal characteristics	
Flesh is almost white	Flesh is yellowish
Flesh does not get dark easily	Flesh may get dark soon
Sugar content is normal (18–24 Brix)	Sugar content is normal
Fruit has a slightly stringent taste	Fruit flavour is smooth and normal
Fruit may be a little acid	Normal flavour
Ripening characteristics	
Fruit may ripen in 4 days at ambient	Fruit may need up to 10 days to ripen
High ethylene production	Low ethylene production
Fruit has a high respiration rate	Fruit has a low–medium respiration rate
Fruit respond to lower ethylene (half)	Fruit respond to normal doses
Fruit has to be ripened at 13.9–15.6°C	Fruit has to be ripened normally
Fruit needs high ventilation	Fruit can be held at normal ventilation
Fruit may taste starchy at Stage 2 or 3	Fruit is already somewhat sweet at Stage 2 or 3
General quality	
Fruit has somewhat strange colour	Fruit colour is normal
Fruit will remain angular when ripe	Fruit will round out as it ripens
Fruit will tend to separate from cluster	Fruit will remain attached to cluster
Fruit may have latex spots	Fruit is absolutely clean
Fruit may have slight insect damage	Fruit is absolutely clean
Fruit is smaller	Fruit is larger
More resistant to crown rot	More susceptible to crown rot
Shelf life	
Fruit should be shipped in Stage 2–3	Fruit may be shipped in Stage 2–3
Fruit will last 3 days at ambient	Fruit will last 4–5 days at ambient
Overripe fruit gets dark soon	Overripe fruit develop dark spots
Ripe fruit may be held at 11°C	Ripe fruit must be held at 13.3–15.6°C
Shorter shelf life	Longer shelf life

7 — Description of Second Trials

Introduction

The trial shipment was described in detail so that every aspect of the fruit handling, from the field to the store, could be monitored to ensure compliance with the established protocol within a given margin of flexibility. The basic protocol was put together by Eric Sauvé from IDRC and reviewed by David Slipacoff (Test Coordinator), Oscar Cruz (Ecos del Agro), and Marco Saenz (Universidad de Costa Rica). All logistics for this test were arranged by David Slipacoff.

The following outline describes the activities for the final trials and some comments. This document is a synthesis of comments from the final report by Marco Saenz and the work protocol by Eric Sauvé. All comments and qualitative or quantitative assessments should be understood as being cited from Saenz (1998).

Field Treatment

Bunches were field bagged with pinhole polyethylene bag at the emergence of the flower. This has successfully kept red spot under control; although the problem is still noticeable in some of the hands. Copper sulfate (organically certified) in low concentrations was used for fumigation.

'Mona Lisa' appears to be losing resistance to black Sigatoka. In the field, plants that some time ago ended with seven to nine functional leaves now only have four or five. This means that the fruit will take longer to fill, the plant is going to be under stress, and quite probably the physiological age of the fruit will not correspond to chronological age so that the fruit may start ripening sooner than previously.

Harvest and Packing

Harvest started on Tuesday 12 May at 6:30 am with bunches that had been hanging 12 weeks after the flower emerged and bent down. The original intention had been to pack one palette each of 12- and 13-week hanging fruit so as to have product for two weekends of consumer demonstrations. This was impossible, however, because there were no actual 12- or 13-week fruit. Ecos lost almost all the 13-week fruit because of Sigatoka: the fruit was so ripe that they had to throw it away. Consequently, fruit ranging between 12 and 13 weeks old was packed. Efforts were made to keep older fruit separate from younger, unfortunately a mix-up several months earlier with the colored-plastic tags used to mark the bunch age made it difficult to determine the exact age of the fruit.

Cushion devices were used to carry bunches, which arrived at the packing house covered with the polyethylene bag that had been placed on the bunch at flowering. Fruit was hung and transported (using the cableway) to the packing house within 30 minutes of picking.

Comment: In general, the operation was fairly careful.

Packing house

In the packing house, flower removal was standard and conventional separation of hands was used to ensure that both enough crown (part of the bunch axis) was left on the hand (defined specifications) and also that the cut was clean. The hand was separated using a "scoop" (sharp semicircle cutting tool). Clusters were selected by cutting each hand into pieces of four to eight fingers and eliminating all those that were deformed. Quality controls were in place to remove bunches that were too deformed or too ripe, or that showed signs of insect damage. "Deformed" characteristics included: misshaped fingers, too much separation between fingers, and other damage (insect, mechanical, and so on).

> **Comment:** The selection was more or less careful; however, because of the volume of rejection and poor quality control systems, unacceptable clusters were often accepted. Eric Sauvé and Marco Saenz assisted in the selection of clusters, further eliminating those unsatisfactory.

Selected clusters were placed in a long tank with flowing water to allow the latex to drain. Based on past experience, it was decided that clusters should remain in the tank for at least 30 minutes. In the case of the first pallet (identified initially as 12-week fruit), tank time approached 60 minutes. For the second pallet (identified initially as 13-week fruit), it was 25 minutes. Grey spot seems less frequent now; however, it still is present in many bunches. Use of calcium chloride (organically approved if there is a clean water rinse after the treatment) may solve this problem. Unfortunately, Oscar Cruz is a little reluctant to use it for certification reasons and so it was not used for this trial.

> **Comment:** No noticeable difference in latex production between the pallets was noted at any point of evaluation through to the consumer.

After latex removal, fruit was placed in fibreglass trays to drain and then moved to the packing area. Selection favoured long hands that were uniform in shape and size: those with very curved fingers, short fingers, clusters with very separated fingers, physical damage and scratches, red spot, gray spot, antrachnosis (*Collectotrichum gloesporioides*), and other damage were avoided. Clusters with four to six fingers were preferred and not more than four clusters of two to three fingers were allowed per box.

> **Comment:** Because the packing house does not operate regularly, training is lacking for the people who select the fruit. Thus selection in the field and at the packing house was not at maximum potential and fruit of less than satisfactory quality was packed. Both Marco Saenz and Eric Sauvé made every possible effort to ensure high quality-control standards by working on the packing line throughout the day.

A packed box of conventional bananas should weigh about 18.9 kg and require 22–24 clusters (note: a cluster contains 4–6 fingers and a bunch contains 12–16 fingers) with tray weight of about 18.7 kg. Normally, every bunch of 'Cavendish' will produce 1–1.2 boxes with an estimated 15–20% rejection. However, in 'Mona Lisa' the rejection rate was estimated at 50% because of deformation of the upper hands — now a major concern — and two bunches were needed to fill a box. The rejection of the upper hands leaves only the middle and base hands for packing and these characteristically show smaller fingers. Also, given the heavy curve of 'Mona

Lisa' fruit, to reach the weight standard, boxes had to be filled beyond the upper edge of the rim thus exposing the fruit to compression and bruising.

> **Comment:** A decision to reduce the weight of the box to 17 kg was made to avoid this problem and 75% of the boxes were packed at this reduced weight.

Both a thick layer of paper and a tubular, perforated liner were placed in the box before the fruit. The fruit was stacked in two levels separated by both the paper and liner for protection. After the fruit was placed in the box, four packages of RETARDER (7 g each) were placed in every box, taking care that the RETARDER was placed inside the liner, close to the fruit, and that the printed surface was not in contact with the fruit (as recommended by RETARDER, Spain). The plastic bags were left open to increase ventilation and evaporation of the humidity inside the carton and each box was stamped with the date of packing.

Transport to Market

The boxes were palletized to form a 1- × 1.2-m form, that is six boxes at base and eight rows high for a total of 48 boxes per pallet, and bound with polypropylene straps reinforced at the corners. Palettes were then loaded into the container at the front positions (away from the refrigeration unit). All floor surfaces were covered with plastic and paper, and the base of the palettes sealed with a polyethylene sheet. Ventilation of the container was set to 25–50% to avoid accumulation of ethylene (C_2H_4)and moisture, and the temperature set between 13.3°–14.4°C. Pulp temperature and air temperature recorders were placed respectively into 'Mona Lisa' pulp as well as in a 'Mona Lisa' box. The 13-week fruit was placed in one palette and another was formed with the 12-week fruit.

The container left from Ecos del Agro at about 2:20 pm on 12 May. And the fruit arrived at the warehouse in Ottawa at about 10 am on 20 May. The fruit was already turning from green to yellow in some fingers in the 13-week palette. This leads us to believe (as indicated earlier) that there were some problems in the tagging of the fruit at the farm before harvest. The temperature, as measured by the warehouse staff of the container was 15.3°C. The Ryan temperature recorder had been stolen. After arrival, a sample box of fruit (randomly selected) was inspected for general quality.

> **Comment:** The major defect found was that the fruit were too small. Most of the boxes carried more than 70% of small fruit. Bruising due to transport was relatively high and skin damage was present; however, there were no problems with latex, gray spots, crown rot, or insect damage. Fruit arrived at stage 1.5. Other factors were within normal range.

Ripening of 'Mona Lisa'

On Wednesday 20 May at 1 pm, the fruit was transhipped to another facility within 2 km. The ripening rooms were normally used for tomatoes (that is, not pressurized ones), but were adequate. The initial plan was that the first palette (marked 13-week fruit) would be distributed for demonstration and sales on the first weekend (23–24 May) and the second (marked 12-week fruit) would be held after ripening for the second weekend. At that point, it was not known whether the second palette would last until the weekend of 30–31 May.

The ripening equipment was set to deliver half the dose of C_2H_4 normally used for 'Cavendish' bananas. In this case, the size of the room required 2.8 L of C_2H_4 to generate the normal doses of C_2H_4 in a 24-hour period. Because the fruit arrived in a advanced stage of ripening, it was decided that half doses (1.4 L) should be used and the fruit exposed for only 12 hours (75 ppm). The temperature was set at 15.5°C.

Fruit was inspected on Thursday morning at 3 am by David Slipacoff and Marco Saenz. On the basis of this inspection, because the fruit had to be ready for Saturday morning, an extra 6-hour treatment (that is, 75 ppm C_2H_4 at 15.5°C) was applied to the fruit. The ripening room was ventilated at 9:20 am on Thursday and 15 boxes were separated and placed in a warmer location within the warehouse building so that the fruit would be fully ripe (stage 4 at least) for the demonstration on Saturday.

At 10:30 am, a sample box from the 13-week palette was brought to IDRC offices and a more formal quality evaluation was done by Marco Saenz, David Slipacoff, and Eric Sauvé together. This box had been in the ripening room for a total of 18 hours and had spent 1 hour at ambient temperature before this review. The box reviewed exhibited the following characteristics:

- Packed at 17 kg.;
- 21 clusters present;
- Length of fruit was between 14 and 17.75 cm with most at 15.25;
- The average diameter was between 3.15 and 3.81 cm;
- Fruit was small in size due to genetic make-up;
- The pulp was white with lots of latex flow;
- One bunch showed signs of latex on the outer skin;
- Almost no latex was left in the liner at the bottom of the box;
- The fruit was clean (only one bunch with latex damage on skin, 5% showed the beginning of antrachnosis, 1 bunch had severe grey spot, 50% had red spot particularly at the contact points between fingers on the upper part of the banana, bruising was not excessive);
- Color was at stage 2, the fruit was full with 5% immature and 95% mature, curvature was variable among the fruit, crowns were well trimmed with no latex on the crown, two bunches had hands with too much separation between fingers, and there were no signs of water loss.

Storage of 'Mona Lisa'

One full pallet was placed in a cold room at 13.3°C along with other boxes of regular bananas. Half a palette was left in the ripening room at 14.4°C to wait until the bananas were delivered to the stores (scheduled for Friday evening, 22 May, and Saturday morning 23 May). Fruit to be sold to the participating stores was delivered on the afternoon of 22 May, so that the stores could have the fruit and look at the quality in advance. It took no more than 1 hour to deliver the fruit to the farthest store. Delivery was done at ambient temperature.

On 28 May at 10 am, one case was sampled from the room at 15.5°C from the warehouse. The box had the following characteristics: no netting, plastic liner open, RETARDER still in the box, fruit at stage 5, firm, 22 bunches, most bunches with red spot, six bunches with latex damage, one with neck problems, and one with grey spot. A second box sampled from warehouse showed: one bunch with latex damage, five to seven bunches with minor bruising, all bruising on skin only having flesh still firm, overall excellent.

At the Retail Store

Because the fruit had arrived a little late into Ottawa and it had to be ready for Saturday 23 May, we recommended to the stores that they do not to place the fruit in the cold room — this is contrary to the suggested protocol. The adaptation was decided based on the ripening stage of the fruit at the time of delivery to the stores.

The fruit for sampling was at stage 3 on Friday afternoon (22 May), so it was decided to move it to a warmer place to accelerate the ripening. It was moved to a room with a temperature of 26°C. The fruit was allowed to warm up and then covered with a plastic bag to trap heat and C_2H_4 inside. Fruit was delivered to stores at stage 4, they were a little underripe on Saturday, but were at stage 5–6 on Sunday morning. Fruit sales for the first weekend were better than expected in some locations (Table 1).

Table 1. Sales of 'Mona Lisa' bananas on first weekend of trial.

Store	Boxes delivered[a]	Sold	Left
Mainstream chain store 1	12	9	1
Mainstream chain store 2	12	5	5
Natural Food Store 1	6	3	1
Natural Food Store 2	10	5	5
Natural Food Store 3	4	1	2

[a] Some of boxes were used for demonstrations.

Reference

Saenz, M.-V. 1998. Market trials of 'Mona Lisa' bananas in Ottawa. International Development Research Centre, Ottawa, ON, Canada. Unpublished internal document.

8 — Survey Instrument for 'Mona Lisa' Banana, Ottawa Consumer Taste Test, 23–24 May 1998

Good (morning/afternoon). I am here representing FoodLinks, a group within the International Development Research Centre. We are assessing the market potential for a new breed of banana, and I would like you to taste one and take a moment to discuss your reaction to it. [Pause while consumer tastes the product]

Imagine you were asked to tell a friend about the 'Mona Lisa' banana. What would you say are its strengths and weaknesses? [Interviewer to check (✔) each attribute]

Attribute	Strength		Neither strength nor weakness	Weakness		dk
	Clear	Modest		Modest	Clear	
Shape						
Colour						
Feel / Texture of peel						
Appearance						
Price @ $0.99/lb.						
Taste						
Size						
Natural food / certified organic						

Which is the biggest strength? The biggest weakness? Please circle both.

There are a variety of attributes associated with the 'Mona Lisa' banana, some of which may influence your decision to purchase it. [Place a check (✔) beside each attribute]

Attribute	Strength		Neither strength nor weakness	Weakness		dk
	Clear	Modest		Modest	Clear	
Helps smaller farmers in developing countries						
Environmentally friendly						
Browns slower when peeled						
The name 'Mona Lisa'						
Thick skin protects from Bruising inside						
Development supported by Canadian government for 13 years						
Naturally resists disease and pests						

Interviewer: Ask client which is the biggest strength? The biggest weakness? Circle them.

Price sensitivity

Because it is more costly for producers, the 'Mona Lisa' is priced higher than the "typical banana." Other organic bananas cost as high as $1.99 per pound. How much would you be willing to pay for the 'Mona Lisa'?

Not willing to pay a premium over typical banana	☐
$0.99 per pound	☐
$1.19 per pound	☐
$1.49 per pound	☐

Consumer Profile

For statistical and analytical purposes, we would like to obtain some basic information about you and your household. The information you provide is treated as strictly confidential and your responses will remain anonymous.

Had you ever heard of an organic banana prior to this taste test?

Yes ☐ No ☐

Male ☐ Female ☐

Age range:

Under 18	☐
18–29	☐
30–39	☐
40–59	☐
60+	☐

Have you ever purchased

organic fresh fruits	☐
or organic fresh vegetables	☐

If "yes", how recently did you purchase organic fresh produce?

Within last two weeks	☐
Within last month	☐
Within last six months	☐

The following are general income categories. Does your household income range:

Under $20,000	☐	$60,001 to $80,000	☐
$20,001 to $40,000	☐	Over $80,000	☐
$40,001 to $60,000	☐		☐

Thinking about your produce shopping, have you ever

Seen organic bananas?	☐
Bought organic bananas?	☐

All things considered, how likely is it that you would buy the 'Mona Lisa' banana next time you are shopping?

Would that be... (check one)

Definitely would purchase them	☐
Very likely	☐
Somewhat likely	☐
Not very likely	☐
No chance at all	☐